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Report on the individual review of the inventory submission of Canada submitted in 2023*

Note by the expert review team

Summary

Each Party included in Annex I to the Convention must submit an annual inventory of emissions and removals of greenhouse gases for all years from the base year (or period) to two years before the inventory due date (decision 24/CP.19). This report presents the results of the individual review of the 2023 inventory submission of Canada, conducted by an expert review team in accordance with the "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories". The review took place from 25 to 30 September 2023 in Gatineau, Canada.

* In the symbol for this document, 2023 refers to the year in which the inventory was submitted, not to the year of publication.

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Abbreviations and acronyms

2006 IPCC Guidelines	*2006 IPCC Guidelines for National Greenhouse Gas Inventories*
2019 Refinement to the 2006 IPCC Guidelines	*2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*
AD	activity data
AGP	active growing period
BOD	biochemical oxygen demand
C	carbon
CF_4	tetrafluoromethane
C_2F_6	hexafluoroethane
CBM-CFS3	Carbon Budget Model of the Canadian Forest Sector
CCS	carbon dioxide capture and storage
CH_4	methane
CO_2	carbon dioxide
CO_2 eq	carbon dioxide equivalent
Convention reporting adherence	adherence to the "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories"
CRF	common reporting format
CSC	carbon stock change
DE	digestible energy
DOC	degradable organic carbon
DOC_f	fraction of degradable organic carbon that decomposes
DOM	dead organic matter
EF	emission factor
ERT	expert review team
FAOSTAT	statistical database of the Food and Agriculture Organization of the United Nations
F_I	stock change factor for input of organic matter
F_{LU}	stock change factor for land-use systems or subsystem for a particular land use
F_{MG}	stock change factor for management regime
$Frac_{leachMS}$	fraction of managed manure nitrogen losses due to leaching and run-off
GHG	greenhouse gas
GWP-100	100-year global warming potential values
HFC	hydrofluorocarbon
HWP	harvested wood products
IE	included elsewhere
IEF	implied emission factor
IPCC	Intergovernmental Panel on Climate Change
IPPU	industrial processes and product use
LULUCF	land use, land-use change and forestry
MCF	methane conversion factor
MMS	manure management system(s)
MSW	municipal solid waste
N	nitrogen
N_2O	nitrous oxide
NA	not applicable
NE	not estimated

NEU	non-energy use
Nex	nitrogen excretion
NF_3	nitrogen trifluoride
NFCMARS	National Forest Carbon Monitoring, Accounting and Reporting System
NFI	national forest inventory
NH_3	ammonia
NIR	national inventory report
NO	not occurring
NO_X	nitrogen oxides
ODS	ozone-depleting substance(s)
OX	oxidation factor
PFC	perfluorocarbon
QA/QC	quality assurance/quality control
SF_6	sulfur hexafluoride
SOC	soil organic carbon
SOC_{REF}	reference soil organic carbon stocks
SWDS	solid waste disposal site(s)
UNFCCC Annex I inventory reporting guidelines	"Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories"
UNFCCC review guidelines	"Guidelines for the technical review of information reported under the Convention related to greenhouse gas inventories, biennial reports and national communications by Parties included in Annex I to the Convention"
VS	volatile solid(s)
Wetlands Supplement	*2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands*
ΔC_G	annual increase in biomass carbon stocks due to growth
ΔC_L	annual decrease in biomass carbon stocks due to losses

I. Introduction

1. This report covers the review of the 2023 inventory submission of Canada, organized by the secretariat in accordance with the UNFCCC review guidelines, particularly part III thereof, namely the "UNFCCC guidelines for the technical review of greenhouse gas inventories from Parties included in Annex I to the Convention" (annex to decision 13/CP.20). The review took place from 25 to 30 September 2023 in Gatineau, Canada, and was coordinated by Roman Payo and Vitor Gois Ferreira (secretariat). Table 1 provides information on the composition of the ERT that conducted the review for Canada.

Table 1
Composition of the expert review team that conducted the review for Canada

Area of expertise	*Name*	*Party*
Generalist	Daniela Romano	Italy
Energy	Vincent Camobreco	United States
	Eunice Alejandra Cortés Alfaro	Mexico
IPPU	Ole-Kenneth Nielsen	Denmark
Agriculture	Marta Alfaro	Chile
LULUCF	Sandro Federici	San Marino
	Bradley Matthews	Austria
Waste	Richard Claxton	United Kingdom
Lead reviewers	Marta Alfaro	
	Daniela Romano	

2. The basis of the findings in this report is the assessment by the ERT of the Party's 2023 inventory submission in accordance with the UNFCCC review guidelines.

3. The ERT has made recommendations that Canada resolve identified findings related to issues.[1] Other findings, and, if applicable, the encouragements of the ERT to Canada to resolve related issues, are also included in this report.

4. A draft version of this report was communicated to the Government of Canada, which provided comments that were considered and incorporated, as appropriate, into this final version of the report.

5. Annex I presents the annual GHG emissions of Canada, including totals excluding and including LULUCF, indirect CO_2 emissions, and emissions by gas and by sector.

II. Summary and general assessment of the Party's 2023 inventory submission

6. Table 2 provides the assessment by the ERT of the Party's 2023 inventory submission with respect to the tasks undertaken during the review. Further information on the issues identified, as well as additional findings, may be found in tables 3 and 5.

Table 2
Summary of review results and general assessment of the 2023 inventory submission of Canada

Assessment		*Issue ID#(s) in table 3 or 5*[a]
Date of submission	Original submission: NIR, 14 April 2023 (body) and 27 July 2023 (annexes); CRF tables (version 2), 14 April 2023	
Review format	In country	

[1] Issues are defined in decision 13/CP.20, annex, para. 81.

Assessment			*Issue ID#(s) in table 3 or 5[a]*
Source of GWP-100	IPCC Fourth Assessment Report		
Application of the requirements of the UNFCCC Annex I inventory reporting guidelines and the Wetlands Supplement (if applicable)	Have any issues been identified in the following areas:		
	(a) Identification of key categories?	No	
	(b) Selection and use of methodologies and assumptions?	Yes	E.11, E.18, A.13, A.19, A.22, L.22, L.26, L.27, W.12
	(c) Development and selection of EFs?	Yes	I.23, A.9
	(d) Collection and selection of AD?	Yes	I.7, I.22, I.17, A.17, A.18, L.16, L.19
	(e) Reporting of recalculations?	No	
	(f) Reporting of a consistent time series?	Yes	I.19, L.5
	(g) Reporting of uncertainties, including methodologies?	No	
	(h) QA/QC?	No	
	(i) Missing categories, or completeness?[b]	Yes	I.16, A.15, A.16, L.1, L.2, L.9, L.11, L.15, L.25, W.7, W.10
	(j) Application of corrections to the inventory?	No	
Significance threshold	For categories reported as insignificant, has the Party provided sufficient information showing that the likely level of emissions meets the criteria in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines?	No	A.8
National inventory arrangements	Have any issues been identified with the effectiveness and reliability of the institutional, procedural and legal arrangements for estimating GHG emissions?	No	
Description of trends	Did the ERT conclude that the description in the NIR of the trends for the different gases and sectors is reasonable?	Yes	
Response from the Party during the review	Has the Party provided the ERT with responses to the questions raised, including the data and information necessary for assessing conformity with the UNFCCC Annex I inventory reporting guidelines and any further guidance adopted by the Conference of the Parties?	Yes	
Recommendation for an exceptional in-country review	On the basis of the issues identified, does the ERT recommend that the next review be conducted as an in-country review?	No	

[a] Further information on the issues identified, as well as additional findings, may be found in tables 3 and 5.
[b] Missing categories for which methods are provided in the 2006 IPCC Guidelines may affect completeness and are listed in annex II.

III. Status of implementation of recommendations included in the previous review report

7. Table 3 compiles the recommendations from previous review reports that were included in the most recent previous review report, published on 11 May 2022,[2] and had not been resolved by the time of publication of the report on the review of the Party's 2021 inventory submission. The ERT has specified whether it believes the Party had resolved, was addressing or had not resolved each issue by the time of publication of this review report and has provided the rationale for its determination, which takes into consideration the publication date of the most recent previous review report and national circumstances.

Table 3
Status of implementation of recommendations included in the previous review report for Canada

ID#	*Issue classification*[a, b]	*Recommendation from previous review report*	*ERT assessment and rationale*
General			
G.1	Inventory submission (G.6, 2021) Transparency	(a) Include in the NIR numerical values for the AD used to estimate GHG emissions for the categories 1.A fuel combustion; 1.B fugitive emissions from oil and gas; 2.B chemical industry; 2.C metal industry; 2.D non-energy products from fuels and solvent use; 2.E electronics industry; 2.F product uses as substitutes for ODS; and 2.G other product manufacture and use; (b) Where the AD have been included in the NIR or otherwise made publicly available, include clear references to annex 3 to the NIR, where the relevant AD could be found.	Resolved. Canada included in the NIR numerical values for the AD used in the estimations and made clear references to where the AD are publicly available, either in the body of the NIR or in annex 3 to the NIR. For category 1.A fuel combustion, Canada reported in the NIR that the AD are taken from the *Report on Energy Supply and Demand in Canada*. In NIR table A3.1-1 (part 2, annex 3), Canada provided references for all AD used in the estimations for fuel combustion. In addition, NIR tables A3.1-2–A3.1-5 (part 2, annex 3) detail the location in the *Report on Energy Supply and Demand in Canada*, specifying for each category and fuel type the table from which the AD are taken. For category 1.B fugitive emissions from oil and gas, Canada reported the sources of the AD and other information (e.g. the status of the well (active or inactive), flaring volumes, number of incidents) in the NIR (part 2, annex 3, section 3.2.2). For categories 2.B–2.G, the AD come from various sources, which are all explained and cited throughout the NIR (part 1, chap. 4, and part 2, annex 3.3). The ERT considers that the information in the NIR is sufficient to find the sources of the AD.
G.2	Uncertainty analysis (G.3, 2021) (G.4, 2019) Convention reporting adherence	Include a quantitative uncertainty assessment for the base year for all source and sink categories.	Resolved. The Party estimated the uncertainty for the base year (±14 and ±3 per cent with and without emissions and removals from LULUCF respectively) for all categories and reported the results in the NIR (part 1, p.29, and part 2, annex 2 to the NIR, pp.11–14 and table A2-1).

[2] FCCC/ARR/2021/CAN. The ERT notes that the report on the review of Canada's 2022 inventory submission has not been published yet owing to insufficient funding for the review process. As a result, the latest previously published annual review report reflects the findings of the review of the Party's 2021 inventory submission.

ID#	*Issue classification*[a, b]	*Recommendation from previous review report*	*ERT assessment and rationale*
Energy			
E.1	1. General (energy sector) – gaseous fuels – CO_2, CH_4 and N_2O (E.1, 2021) (E.1, 2019) (E.1, 2017) (E.2, 2016) (E.4, 2015) (19, 2014) Accuracy	(a) Take steps to ensure that the conversion of volumes of natural gas to energy units is completed appropriately for both marketable and non-marketable natural gas; (b) Document the progress of efforts in the improvement plan and in the NIR.	(a) Resolved. The Party reported in annex 6.1.1.1 to the NIR (part 2) CO_2 EFs for both marketable and non-marketable natural gas per region and per year in physical units (g/m^3) rather than energy units. During the review, the Party clarified that all AD are collected in physical units and that information in gross calorific units is less accurate because up-to-date energy content values are not always available. Therefore, the Party's calculation methodology is based on EFs, per region and per year, in physical units, which are estimated by sampling and direct measurement. Energy conversion factors are applied for the reporting of fuel quantities in the CRF tables, and nationally weighted values are determined for reference approach calculations. For natural gas, the conversion of volumes to energy units is based on country-specific weighted values that are determined from the proportion of marketable and non-marketable natural gas. The ERT considers that the accuracy issue is resolved but a comparability issue remains (see ID# E.14 in table 5); (b) Resolved. The Party reported in its NIR (part 1, section 3.2.4.6, p.73) that Environment and Climate Change Canada, Natural Resources Canada and Statistics Canada continued to collaborate on improving the quality of the national energy balance and the disaggregation of fuel-use data through the Trilateral Energy Working Group.
E.2	1. General (energy sector) – all fuels – CO_2, CH_4 and N_2O (E.2, 2021) (E.4, 2019) (E.4, 2017) (E.25, 2016) Accuracy	Update CO_2 EFs where appropriate (following the plan referred to in ID# E.3 in document FCCC/ARR/2016/CAN) and provide references for these in the NIR.	Resolved. The Party reported in annex 6.1 to the NIR (part 2) revised CO_2 EFs for all years. These EFs were implemented in the 2022 submission for the first time. The Party presented EFs for both marketable and non-marketable natural gas. For example, NIR table A6.1-2 (part 2, annex 6) now includes CO_2 EFs for non-marketable natural gas for all years and all provinces as opposed to the aggregated EFs used in prior reports.
E.3	1. General (energy sector) – all fuels – CO_2, CH_4 and N_2O (E.3, 2021) (E.5, 2019) (E.5, 2017) (E.25, 2016) Transparency	(a) Document all instances where the calorific values and/or the CO_2 EFs deviate from the ranges set out in the 2006 IPCC Guidelines; (b) Provide concise explanations of the reasons for these deviations; where the reasons are not understood, investigate them.	(a) Resolved. The Party's emissions are based on AD in physical units so calorific values are not as critical as CO_2 EFs for comparison. The Party reported in its NIR (part 2, section A.6.1.3.1) revised anthracite CO_2 EFs for 1990–2021. The revised value (3,097 kg CO_2/t) is now in line with the default value range (2,043–3,252 kg CO_2/t) in the 2006 IPCC Guidelines (vol. 2, tables 1.2 and 2.2). During the review, the Party clarified that it applies country-specific EFs in line with the IPCC tier 2 and tier 3 combustion approach as per paragraph 12 of the UNFCCC Annex I inventory reporting guidelines. The ERT considers that the recommendation has been fully addressed and agrees that the approach is in line with paragraph 12 of the UNFCCC Annex I inventory reporting guidelines but considers that the transparency of the Party's approach could be improved and thus raised a new issue (see ID# E.14 in table 5); (b) Resolved. The Party provided the EFs used in annex 6 to its NIR (part 2) and explained the methods, including the AD, used in annex 3 to its NIR (part 2). In

ID#	Issue classification[a, b]	Recommendation from previous review report	ERT assessment and rationale
			addition, the NIR includes references to the studies on the EFs used that explain in detail why the EFs are applicable to Canada's circumstances.
E.4	1.A.3 Transport – liquid fuels – CO_2 (E.5, 2021) (E.12, 2019) (E.26, 2017) Accuracy	Estimate CO_2 emissions from lubricants combusted in two-stroke engines separately using appropriate OXs and report them in the energy sector.	Resolved. The recommendation was addressed by estimating the volumes of lubricants combusted in two-stroke engines and multiplying the results by a CO_2 EF derived for those lubricants. The emissions from combustion of lubricants in two-stroke engines were reported under category 1.A.3.e.ii, and an appropriate adjustment was made to lubricant reporting under category 2.D.3 to avoid any double counting. The Party reported both the methodology used to estimate these emissions (NIR part 2, annex 3, section 3.1.4.2.1) and the EF (NIR part 2, annex 6, section 6.1.6).
E.5	1.A.3 Transport – liquid fuels – CO_2, CH_4 and N_2O (E.6, 2021) (E.13, 2019) (E.27, 2017) Transparency	Finalize the update of the methodological documentation on the Motor Vehicle Emissions Simulator and Nonroad Engines, Equipment and Vehicles models and include a summary of the documentation in the NIR.	Addressing. The Party reported in its NIR (part 2, annex 3, section 1.4.2) information regarding the use of the Motor Vehicle Emissions Simulator and Nonroad Engines, Equipment and Vehicles models and a general overview of how the information from these models was used, but the methodological documentation lacked detail. During the review, the Party clarified that it was unable to finalize the methodological documentation for either model and that it is likely that the finalization of the methodological documentation will not be ready until the 2025 inventory submission. The Party mentioned that, for the 2024 inventory submission, it plans to better describe the models in the NIR while referencing their technical documentation, which is openly available from the United States Environmental Protection Agency.
E.6	1.B.1.a Coal mining and handling – solid fuels – CH_4 (E.8, 2021) (E.27, 2019) Comparability	Report the production data for subcategory 1.B.1.a.i.1 in the correct unit of measurement in CRF table 1.B.1.	Resolved. The production data for subcategory 1.B.1.a.i.1 mining activities (underground mines) are reported with the correct unit (Mt) in CRF table 1.B.1.
E.7	1.B.1.a Coal mining and handling – solid fuels – CO_2 (E.9, 2021) (E.19, 2019) (E.17, 2017) (E.20, 2016) (E.29, 2015) Transparency	(a) Report the CO_2 emissions from underground mines as "NA"; (b) Indicate in the NIR that no CO_2 emissions associated with flaring and drainage systems of underground mines occur in the country.	(a) Resolved. The Party reported CO_2 emissions from underground mines in category 1.B.1.a.i as "NA" across the time series in CRF table 1.B.1; (b) Resolved. The Party reported in its NIR (part 1, section 3.3.1.2, p.85) that there were no CO_2 emissions from flaring or drainage activities at any mine in Canada. The issue addressing the lack of documentation to support this statement in the NIR is covered under ID# E.16 in table 5.
E.8	1.B.1.b Solid fuel transformation – solid fuels – CO_2 and CH_4 (E.10, 2021) (E.22, 2019) (E.20, 2017) (E.33, 2016) Transparency	Report CO_2 and CH_4 emissions from briquette manufacturing under solid fuel transformation. If this cannot be done, use the correct notation key for solid fuel transformation ("IE" instead of "NE") and update the description in the NIR accordingly.	Resolved. The Party reported CO_2 and CH_4 emissions from briquette manufacturing under category 1.B.1.b solid fuel transformation as "NE" in CRF table 1.B.1. The Party reported in its NIR (part 1, section 3.3.1.1, p.84) that there is currently only one facility in Canada engaged in briquette manufacturing and reliable data were only available for the year when the plant's peak production (100 kt) occurred. Using the default EF values of 1,570 g CO_2/kg and 40.3 g CH_4/kg from the 2019

ID#	*Issue classification*[a, b]	*Recommendation from previous review report*	*ERT assessment and rationale*
			Refinement to the 2006 IPCC Guidelines (vol. 4, chap. 4.3.2.1, p.4.103) and the peak production value (100 kt), the likely level of emissions from this source would be at most 260 kt CO_2 eq. This likely level of emissions is below the significance threshold established in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines (0.05 per cent of national total emissions excluding LULUCF for the latest reported year (i.e. 335.21 kt CO_2 eq for Canada's 2023 submission) and not exceeding 500 kt CO_2 eq), so the Party chose to report these emissions as "NE".
E.9	1.B.1.b Solid fuel transformation – solid fuels – CO_2 and CH_4 (E.11, 2021) (E.23, 2019) (E.21, 2017) (E.33, 2016) Transparency	Document the methodology and data sources used to estimate emissions from briquette manufacturing in the NIR.	Resolved. The Party documented in its NIR (part 1, section 3.3.1.1, p.84) the methodology and sources of data used to estimate emissions from briquette manufacturing and the justification for reporting them as "NE" in CRF table 1.B.1 for category 1.B.1.b emissions from solid fuel transformation (see ID# E.8 above).
E.10	1.C CO_2 transport and storage – all fuels – CO_2 (E.12, 2021) (E.25, 2019) (E.30, 2017) Transparency	Provide transparent information on the subcategories under which the fugitive CO_2 emissions from the two CO_2 enhanced oil recovery projects are reported and how the Party ensures comprehensive coverage of fugitive CO_2 emissions from these projects in the NIR.	Resolved. The Party reported in its NIR (part 1, section 3.4, p.96) that some of the AD associated with carbon capture cannot be disaggregated and reported only under category 1.C CO_2 transport and storage. These emissions, including fugitive emissions from projects that use CO_2 injection to enhance oil production, are reported under subcategories 1.B.2.a.2 oil – production, 1.B.2.c.1.i venting – oil and 1.B.2.c.2.i flaring – oil in the CRF tables. The Party ensures comprehensive coverage of fugitive CO_2 emissions by accounting for the net impact of GHG emissions from all carbon capture activities in its inventory as part of categories 1.A.1 energy industries, 1.B.2 oil and natural gas and 1.C CO_2 transport and storage (NIR part 1, p.96).
E.11	1.C.2 Injection and storage – CO_2 (E.13, 2021) Comparability	(a) Estimate and report under subcategory 1.C.2.b storage the cumulative closing stock amount of CO_2 for each year of the time series since the commencement of CO_2 injection in both long-term storage and operational enhanced oil recovery formations, taking into account the volumes injected and lost as fugitive emissions during production for each year of the time series and reported in CRF table 1.B.2 in accordance with footnotes 1 and 3 to CRF table 1.C; (b) Report all CO_2 injected for both enhanced oil recovery and CCS activities in subcategory 1.C.2.a injection.	(a) Addressing. The Party reported the cumulative closing stock amount of CO_2 for each year of the time series since the commencement of CO_2 injection in long-term storage under category 1.C.2.b in CRF table 1.C. However, information on fugitive emissions from operational enhanced oil recovery formations is included under category 1.B.2 and in NIR chapter 3. During the review, the Party clarified that when enhanced oil recovery formations are closed and converted to long-term storage, the yearly amount stored will be recorded in yearly reporting on fugitive emissions in CRF table 1.C in order to ensure that any generated emissions are presented for the lifetime of the site as enhanced oil recovery to storage. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet reported the cumulative closing stock amount of CO_2 for each year of the time series since the commencement of CO_2 injection for operational enhanced oil recovery formations; (b) Addressing. The Party reported the CO_2 injected for CCS activities in CRF table 1.C (subcategory 2.a). However, it reported CO_2 injected in enhanced oil recovery formations in table 1.C (subcategory 2.b). During the review, the Party clarified that this will probably not be an issue in future reporting under the enhanced

ID#	Issue classification[a, b]	Recommendation from previous review report	ERT assessment and rationale
			transparency framework under the Paris Agreement owing to changes to the reporting tables. However, the ERT notes that the 2023 submission and its review are carried out under the current reporting and review guidelines and, as a result, considers that the recommendation has not yet been fully addressed because the Party has not yet reported CO_2 injected for enhanced oil recovery in CRF table 1.C under subcategory 2.a injection.
E.12	1.C.2.b Storage – CO_2 (E.14, 2021) Transparency	(a) Noting that both enhanced oil recovery and CCS operations should be included in the reporting, document in the NIR the basis for concluding that emissions from the geological formations are not occurring, including evidence of applicable monitoring and/or modelling throughout the time series from the commencement of CO_2 injection;	(a) Addressing. The Party continued to report CO_2 emissions for subcategory 1.C.2.b storage as "NO" in CRF table 1.C. The Party reported in its NIR (part 1, p.95) that modelling and simulation results from the first phase (2000–2004) of a CO_2 monitoring and storage project managed by the Petroleum Technology Research Centre indicate that, after enhanced oil recovery operations are completed, more than 98 per cent of CO_2 will remain trapped in the Weyburn enhanced oil recovery site after 5,000 years, with only 0.14 per cent of the remainder released to the atmosphere.
		(b) If the Party cannot demonstrate that fugitive emissions from the geological formations subject to CCS and/or enhanced oil recovery operations are estimated for each year of operation, report emissions for subcategory 1.C.2.b storage using the notation key "NE".	During the review, the Party clarified that the long-term storage and enhanced oil recovery sites related to the Quest Carbon Capture System, Boundary Dam Power Station facility and Clive enhanced oil recovery field are extensively tested and measured and that there has been no measured leakage at any of these sites. The Party also explained that the Weyburn enhanced oil recovery site is the subject of a long-term study and has also shown no leakage. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet included evidence of applicable monitoring and/or modelling throughout the time series (the NIR references only monitoring from 2000 to 2004). The ERT suggests that the Party add information in the NIR on the testing and measurement of the Quest Carbon Capture System, Boundary Dam Power Station facility and Clive enhanced oil recovery field, and recent information on the long-term study of the Weyburn enhanced oil recovery site; (b) Not resolved. The Party reported CO_2 emissions from storage as "NO" in CRF table 1.C but did not justify in the NIR use of this notation key for the entire time series (see (a) above). However, during the review, the Party described studies indicating that emissions from the geological formations are not occurring (see (a) above). The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet demonstrated in the NIR that fugitive emissions from the geological formations are not occurring for the entire time series.
IPPU			
I.1	2.A.1 Cement production – CO_2 (I.21, 2021) Comparability	Collect complete AD for clinker production for 2017 and 2018 and report updated AD in the CRF tables, ensuring that reported CO_2 IEFs are accurate.	Resolved. Canada collected the missing data from some facilities and updated the AD for 2017 and 2018, which has brought the IEFs (e.g. from 0.63 to 0.51 t/t for 2018) within the range of those of other Parties.

ID#	*Issue classification*[a, b]	*Recommendation from previous review report*	*ERT assessment and rationale*
I.2	2.A.1 Cement production – CO_2 (I.22, 2021) Transparency	Explain in the NIR the measures taken to ensure time-series consistency of CO_2 EFs and corresponding CO_2 emission estimates for category 2.A.1 cement production, including information on the splicing technique used and assumptions made for this purpose.	Resolved. Canada provided information in the NIR (part 1, p.102) on how time-series consistency has been assessed and ensured using the splicing technique from the 2006 IPCC Guidelines (vol. 1, chap. 5, pp.8–13), including information on the assumptions made.
I.3	2.A.2 Lime production – CO_2 (I.23, 2021) Transparency	Explain in the NIR the measures taken to ensure the time-series consistency of CO_2 EFs and corresponding CO_2 emission estimates for category 2.A.2 lime production, including information on the splicing technique used and assumptions made for this purpose.	Resolved. Canada provided information in the NIR (part 1, p.104) on how time-series consistency has been assessed and ensured using the splicing technique from the 2006 IPCC Guidelines (vol. 1, chap. 5, pp.8–13), including information on the assumptions made.
I.4	2.A.4 Other process uses of carbonates – CO_2 (I.2, 2021) (I.2, 2019) (I.2, 2017) (I.2, 2016) (I.10, 2015) Completeness	Include CO_2 emissions from ceramics production in the inventory or demonstrate that the emissions are insignificant, as defined in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines.	Resolved. Canada provided information in the NIR (part 1, section 4.4.1, p.105) showing that the likely level of emissions from ceramics production (23–54 kt CO_2 eq for 2005–2007 and 2011–2021) is well below the significance threshold established in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines (0.05 per cent of national total emissions excluding LULUCF for the latest reported year (i.e. 335.21 kt CO_2 eq for Canada's 2023 submission) and not exceeding 500 kt CO_2 eq).
I.5	2.B.1 Ammonia production – CO_2 (I.24, 2021) Accuracy	(a) Improve the accuracy of its emission estimates by fully applying the stoichiometric recovery factor of 0.733 kg CO_2/kg urea for CO_2 emission estimates in category 2.B.1 ammonia production; (b) If explicitly accounting for CO_2 emissions during urea production, report such emissions in category 2.B.10 other and simultaneously subtract these CO_2 emissions from the CO_2 emissions reported in category 2.B.1 ammonia production in order to avoid double counting.	(a) Resolved. Canada applied the stoichiometric factor of 0.733 kg CO_2 per kg urea for the emission estimates reported in the submission and documented this in the NIR (part 1, pp.110–111); (b) Resolved. Canada changed the calculation as detailed under point (a) above and this issue is therefore not applicable.
I.6	2.C.1 Iron and steel production – CO_2 (I.6, 2021) (I.11, 2019) (I.7, 2017) (I.4, 2016) (I.5, 2015) (37, 2014) Transparency	Include the allocation of NEU of other reductants identified in this category in the improvement plan and implement steps to further disaggregate the energy statistics and other (industrial processes) category.	Addressing. Canada included in the NIR (part 1, pp.127–128) the planned improvements for implementing this recommendation. During the review, Canada presented the progress made and indicated that there was a good possibility that NEU of natural gas could be identified and the emissions reallocated to the IPPU sector. The ERT considers that the recommendation has not yet been fully addressed.
I.7	2.C.1 Iron and steel production – CO_2	Collect AD for direct iron reduction for 2013–2016 and report updated AD in the CRF tables, ensuring that reported CO_2 IEFs are accurate or,	Addressing. Canada did not revise the AD reported for pig iron and included this issue in the list of planned improvements in the NIR (part 1, p.128). During the review, Canada explained that AD have been received from the producers

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	(I.25, 2021) Comparability	if this is not possible, provide a clear explanation of the issue in the NIR.	association and will be used for the 2024 submission. The ERT was provided with spreadsheets containing the revised AD and provisional estimations and noted that the IEFs now reflect the natural inter-annual changes for these processes throughout the time series. The ERT considers that the issue will be fully resolved in the 2024 submission when Canada uses the updated AD.
I.8	2.C.3 Aluminium production – CO_2, PFCs and SF_6 (I.7, 2021) (I.13, 2019) (I.22, 2017) Transparency	Include information on the shares of process-related emissions from aluminium production estimated using different methodological tiers across the time series in the NIR.	Resolved. Canada provided information in NIR table 4-9 (part 1, p.129) on the methodological tier used for each plant in Canada for CO_2, PFCs and SF_6. It was clear to the ERT that for all plants and gases the tier 3 methodology has been used since 2017. SF_6 emissions were estimated using the tier 3 methodology throughout the time series. CO_2 emissions were estimated using the tier 3 methodology for the majority of plants since 2008, with the last plants moving to the tier 3 methodology in 2017. For PFCs, implementation of the tier 3 methodology was more spread out over time, but this is clearly described in NIR table 4-9. The tier 1 methodology was not applied at any time during the time series.
I.9	2.C.3 Aluminium production – CO_2 (I.26, 2021) Comparability	Collect complete AD for aluminium production for 2019 and report updated AD in the CRF tables, ensuring that reported CO_2 IEFs are accurate.	Resolved. Canada collected the missing AD for 2019 and the value of the CO_2 IEF for 2019 is no longer an outlier compared with the rest of the time series. The CO_2 IEF for 2019 was 1.92 t/t and 1.66 t/t in the 2021 and 2023 submissions respectively. The IEF now falls within the range of the IEFs for the other years (1.63–1.74 t/t).
I.10	2.C.3 Aluminium production – PFCs (I.27, 2021) Comparability	(a) Report aluminium production AD for CF_4 and C_2F_6 by-product emissions in CRF table 2(II).B-Hs1 in t rather than kt; (b) Ensure that the respective IEFs are accurate and expressed in kg/t.	(a) Resolved. Canada provided the AD in t rather than kt in CRF table 2(II).B-Hs1 as required; (b) Resolved. As the AD have been corrected and the IEFs are automatically calculated by CRF Reporter, the IEFs are now correct.
I.11	2.C.3 Aluminium production – SF_6 (I.28, 2021) Comparability	(a) Improve the comparability and transparency of reporting by selecting appropriate AD following the approach used for reporting SF_6 emission estimates in CRF table 2(II).B-Hs1 for category 2.C.3 aluminium production; (b) Accurately report AD and related IEFs using the appropriate units.	(a) Resolved. Canada changed the AD reported in CRF table 2(II).B-Hs1 to SF_6 consumed rather than aluminium produced to match the methodology used to estimate emissions; (b) Resolved. Canada changed the AD, and the IEFs reflect the change. The AD description in the CRF table still says "Amount of aluminium casted" where it should be "Amount of SF_6 used". However, it is not possible for Parties to change this in CRF Reporter and as Canada transparently provides this information in the NIR, the issue is considered to be resolved.
I.12	2.C.4 Magnesium production – CO_2 (I.9, 2021) (I.29, 2019) Comparability	Correct the notation key reported in CRF table 2(I).A-H for category 2.C.4 for CO_2 emissions from "NA" to "NO" for years during which primary magnesium production did not occur.	Resolved. Canada reported the correct notation key ("NO") in CRF table 2(I).A-H for the years in which primary magnesium production is not occurring in Canada (2009–2021).
I.13	2.D Non-energy products from fuels and solvents use – CO_2 and CH_4	Implement the scheduled improvements for this category, report on progress and continue the	Not resolved. The Party continued to report the country-specific subcategory other and undifferentiated under category 2.D.3 other. The ERT noted that the planned improvements described in the NIR for the past several years (part 1, p.134, in the

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	(I.12, 2021) (I.17, 2019) (I.12, 2017) (I.8, 2016) (I.6, 2015) (37 and 41, 2014) (47, 2013) (78, 2012) (77, 2011) Transparency	improvements necessary to document the methods and sources of AD and EFs in the NIR.	2023 submission) for this category have not been implemented. The ERT also noted that the recommendations from the previous review reports relate to both AD and EFs and, while both aspects are relevant, the ERT considers that the most critical improvement to be made is to better understand the AD, including to what extent the NEU of fuels is emissive. During the review, Canada explained that a large fraction of the AD, and hence emissions, reported for this category is from "petroleum used for other products", and that there is no specific information available as to the nature of this fuel use. On the basis of the explanation provided, the ERT considers it likely that the large fraction could represent intermediate products that in reality would not lead to emissions. The ERT suggests that Canada prioritize the work to address the AD, including the emissive nature of NEU of fuels. Collaboration with Statistics Canada will probably be needed to obtain good-quality information. The ERT considers that the improvements related to the EFs, while relevant, will have a much smaller impact on the emissions and should therefore be secondary to the improvements related to the AD.
I.14	2.F Product uses as substitutes for ODS – PFCs (I.16, 2021) (I.23, 2019) (I.25, 2017) Completeness	Estimate all PFC emissions in category 2.F using the 2006 IPCC Guidelines, making appropriate revisions to the NIR to reflect the use of the updated methodologies.	Resolved. Canada described in the NIR (part 1, pp.142–143) the status of PFC use for each subcategory. The Party reported emissions from some subcategories, such as fire protection and aerosols, as negligible. During the review, Canada provided comparisons with data reported by other Parties that showed that any emissions from PFCs used for these purposes would be negligible. The ERT agrees with this assessment, as PFCs are generally not used extensively for these purposes.
I.15	2.F Product uses as substitutes for ODS – HFCs and PFCs (I.29, 2021) Accuracy	Reassess available AD on HFC and PFC mixtures in category 2.F product uses as substitutes for ODS for the complete time series, in particular for 2008–2020, and consider them in a revision of the PFC emission estimates and, if applicable, HFC emission estimates, for all categories and subcategories under category 2.F.	Resolved. Canada implemented the planned correction of the AD for categories 2.F.1 refrigeration and air conditioning and 2.F.5 solvents for the 2022 submission and described the recalculation in the 2022 NIR (part 1, p.140) because the recalculation was performed for the 2022 submission for the first time.
I.16	2.G.2 SF_6 and PFCs from other product use – PFCs and SF_6 (I.18, 2021) (I.34, 2019) Completeness	Investigate whether the SF_6 and PFC uses mentioned in the 2006 IPCC Guidelines (vol. 3, chap. 8.3) occur in the country. If emissions from such uses do not occur, report them as "NO". If such emissions do occur, estimate and report them or, if they are considered insignificant, report them as "NE", provide in the NIR a justification for the insignificance, in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines, and explain in CRF table 9 why these emissions are reported as "NE".	Addressing. The Party reported SF_6 and PFCs from other product use as "NE" in the CRF tables and provided explanations in CRF table 9 indicating the lack of data to provide such estimates. Canada included in the NIR (part 1, p.147), in the list of planned improvements, conducting a survey for gas distributors and contacting relevant stakeholders (e.g. experts knowledgeable on particle accelerator and ophthalmology uses). During the review, Canada informed the ERT that it has contacted the United States Environmental Protection Agency to investigate whether data on SF_6 exports to Canada could be collected. The ERT noted that using a top-down approach based on import/export data might be simpler than attempting to estimate consumption in a bottom-up manner, as SF_6 can be used in many places (e.g. hospitals and research institutions). The ERT considers that Canada has started to address the recommendation through its contact with the United States

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			Environmental Protection Agency, but that substantial work is still needed to resolve this issue, including continuing the work on acquiring import data and use data (e.g. through contact with gas distributors).
I.17	2.G.4 Other (other product manufacture and use) – PFCs (I.19, 2021) (I.35, 2019) Comparability	Report on PFCs used in electronic insulators and for heat transfer in the electronics industry under category 2.E.1 instead of category 2.G.4.	Addressing. Canada reallocated AD previously reported for the use of PFCs as a heat transfer medium for 2014–2018 to category 2.F.1 (refrigeration and air conditioning) for use as refrigerants for the 2022 submission onward, instead of to category 2.E.1 (integrated circuit or semiconductor). The reallocation of other AD currently reported under category 2.G.4 (other (other product manufacture and use)) to other applications is part of the planned improvements and has not yet been implemented.
Agriculture			
A.1	3. General (agriculture) – CH_4 (A.2, 2021) (A.12, 2019) Transparency	(a) Provide in the NIR sufficient information and data on the categorization of animal used (subcategory list and a description of the subcategories used in the estimations), AD (number of animals per province and subcategory of animal), parameters (i.e. MCF, VS, biodegradability of manure, animal waste management systems, Nex rate, weight, daily weight gain, mature weight, mean winter temperature, milk production, milk fat content, percentage of females that give birth in a year, number of offspring, feed digestibility and any other parameter used in the estimations), equations and EFs used for the estimates of enteric fermentation and manure management of dairy cattle, non-dairy cattle and swine at the level of disaggregation used in the estimations; (b) Explicitly explain changes along the time series (e.g. if weight changes between subcategories and provinces, report the information at the subcategory and regional level).	(a) Addressing. The Party reported in its NIR (part 2, annex 3, section A3.4, p.92) the methodologies used to estimate emissions for the sector, including the rationale followed for selecting various parameters and the assumptions made for categories estimated using the tier 2 methodology (categories 3.A (for cattle and non-dairy cattle) and 3.B (for cattle and non-dairy cattle, and swine)). During the review, the Party explained that efforts to improve the transparency of reporting across the agriculture sector are ongoing (see also ID# A.2 below). The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet provided disaggregated information at the regional level for all parameters used in the estimation of emissions for cattle and non-dairy cattle under category 3.A and for cattle and non-dairy cattle, and swine, under category 3.B; (b) Addressing. The Party reported in its NIR (part 2, section A.3.4.1, pp. 97–104, and table A.3.4.9, p.109) information on the estimation of weight changes along the time series for key animal categories (see also ID# A.5 below). During the review, the Party explained that efforts are being made to increase the transparency of reporting across the sector (see also ID# A.2 below). The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet provided disaggregated information at the regional level at which the estimates were made.
A.2	3. General (agriculture) – CH_4 (A.3, 2021) (A.12, 2019) Transparency	Provide clear references for the sources of the data, parameters and EFs, as well as documentation on any assumption used in the calculations following the protocol for expert elicitation included in the 2006 IPCC Guidelines (vol. 1, annex 2A.1, chap. 2).	Addressing. The Party reported in its NIR (part 2, section A.2.4.1, p.94, to section A.3.4.3, p.124) and CRF tables 3.As2, 3.B(a)s1 and 3.B(a)s2 the sources of the AD and the assumptions used to estimate country-specific EFs. However, the assumptions are based on two documents (Marinier, Clark and Wagner-Riddle, 2004, 2005) that are not publicly available and were published 20 years ago, so data included in these documents most likely do not reflect current manure management practices, as indicated by the Party in relation to the intensification of dairy and beef

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			production in Canada over the last 20 years. Thus, Canada did not provide updated and comprehensive documentation in accordance with the protocol for expert elicitation included in annex 2A.1 to the 2006 IPCC Guidelines (vol. 1, chap. 2). As a result, it was not possible for the ERT to cross-check the information provided for MMS and for the trend in CH_4 EFs from manure. During the review, the Party provided the documentation required and explained that to increase the transparency of its submissions, it is separating methodological information, including assumptions, from data on results so that written documentation on the calculation steps can be integrated using the R Markdown language. NIR documentation will be maintained in the code, so that when methodological changes occur, the automatic updating of documentation on demand in Word or portable document format will be possible. The Party indicated that this system will be tested in 2024 and will be fully in place for the 2026 submission. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet transparently reported all the sources used for MMS in Canada and the trend in CH_4 EFs for manure.
A.3	3. General (agriculture) – CH_4 (A.4, 2021) (A.12, 2019) Transparency	Provide a clear explanation of the rationale for selecting the various parameters and assumptions. The information provided must be detailed enough to clearly follow any estimation included in the Excel estimation files.	Resolved. The Party reported in its NIR (part 2, section A3.4, p.92) the methodologies used to estimate emissions for the sector, including the rationale followed for selecting various parameters and the assumptions made for categories estimated using the tier 2 approach (categories 3.A enteric fermentation, 3.B manure management and 3.D agricultural soils). The Party did not include in the NIR a comprehensive description of all parameters used in the estimations carried out following the tier 2 approach for those categories. However, the ERT notes that ID#s A.1 and A.2 above already recommend that Canada provide that information, so the ERT considers that this issue is redundant and decided to close it. During the review, Canada explained that estimations for the agriculture inventory are not produced using Excel spreadsheets owing to the level of complexity and volume of underlying data but rather using a series of more than 50 interconnected relational databases. In addition, it noted that work on the implementation of a data and reference management system is under way (see ID# A.2 above).
A.4	3. General (agriculture) – CH_4 (A.5, 2021) (A.12, 2019) Transparency	Where a model is used to obtain any parameter or EF used in the estimates (e.g. swine growth model), provide the following information, as suggested in the IPCC (2011) document *Use of Models and Facility-Level Data in Greenhouse Gas Inventories*, to assess the model: basis and type of model (statistical, deterministic, process-based, empirical, top-down, bottom-up, etc.); application and adaptation of the model; main equations and processes; key assumptions;	Addressing. The Party reported in its NIR (part 2, section A3.4, p.92) the methodologies for developing country-specific EFs to be applied in the tier 2 approach, including the rationale followed for selecting various parameters and the assumptions made (for categories 3.A enteric fermentation and 3.B manure management; see ID#s A.2 above and A.11(b) below). However, no detailed information was provided on the model used, its calibration, its validation, the respective uncertainty and sensitivity analyses, and the QA/QC procedures adopted in the NIR or an annex to the NIR or as a reference to a report or publication.

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		domain of application; how the model parameters were estimated; description of key inputs and outputs; details of calibration and evaluation with calibration data and independent data; description of the approach to the uncertainty and sensitivity analyses, and the results of these analyses; QA/QC procedures adopted; and references to peer-reviewed literature. If the information is too extensive to be included in the NIR, even as an annex, publish all of the information requested in a publicly available methodological report and reference that document in the NIR as a source of information.	During the review, the Party clarified that when referring to a model it refers to the approach used to derive key parameters from the characteristics of farm production systems and indicated that work to address this issue is ongoing (see ID# A.2 above). The Party noted that it will try to improve the information included in the next NIR. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet provided a comprehensive description of all parameters used in the estimations carried out following the tier 2 approach at the regional level for the agriculture sector (categories 3.A and 3.B) or information on the calibration, validation, sensitivity analysis and QA/QC procedures used in preparing these estimates.
A.5	3.A.1 Cattle – CH_4 (A.6, 2021) (A.13, 2019) Transparency	(a) Provide in the NIR a clear description of the production subcategories of dairy cattle to facilitate understanding of their main characteristics; (b) Provide in the NIR a clear description of the AD, parameters and methodologies used to explain the weight values of dairy cattle and describe how these values can be replicated; (c) Provide in the NIR a transparent justification of the daily weight gain of mature dairy cows; (d) Explain in the NIR why there is no change in the average daily weight gain linked to feed quality.	(a) Resolved. The Party reported in NIR tables A3.4-2–A3.4-3 (part 2, pp.96–97) the cattle production stage approach and the typical characteristics of Canadian dairy production systems used in the estimation of enteric fermentation emissions from dairy cattle, including the main characteristics of animal subcategories of dairy production; (b) Resolved. The Party reported in its NIR (part 2, section A3.4.1, p.97) a description of the AD, parameters and methodologies used in order to explain variations in the weight of animals; (c) Resolved. The Party reported in its NIR (part 2, section A3.4.1, p.97) that in the tier 2 approach followed to estimate enteric emissions from dairy cattle, a time series consisting of the annual weighted provincial averages for feed digestibility, lactation length and crude protein content in feed was transferred into the existing methodology following the approach of Boadi et al. (2004), and that provincial cattle weights for dairy animals were modified on the basis of average measurements included in the Lactanet national database for each farm size and productivity class. The percentage change in cattle weight was used as an indicator of changes in average body weight, mature weight and weight gain from the 2001 benchmark values established by Boadi et al. (2004); (d) Resolved. Canada included in its NIR (part 2, section A3.4.1, p.97) an explanation of how the time series for average daily weight gain linked to feed digestibility was built (see also (c) above).
A.6	3.A.1 Cattle – CH_4 (A.7, 2021) (A.14, 2019) Transparency	(a) Provide a clear description of the production subcategories of cattle in the NIR to facilitate understanding of their main characteristics;	(a) Resolved. The Party reported in NIR tables A3.4-2–A3.4-3 (part 2, pp.96–97) the cattle production stage approach and the typical characteristics of Canadian dairy production systems used in the estimation of enteric fermentation emissions from

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		(b) Provide quantitative and qualitative information on the values used for all parameters involved in the tier 2 estimation of enteric fermentation at the regional level, including detailed references to the sources of the information and assumptions used; (c) Ensure consistency when determining the parameters by region and animal type by developing a transparent protocol by which to assign the values and revise the estimates, when appropriate.	dairy cattle, including the main characteristics of animal subcategories (see also ID# A.5(a) above); (b) Addressing. The Party reported in its NIR (part 2, section A3.4.1, pp.94–103) quantitative data and qualitative descriptions of livestock production systems (for dairy and non-dairy cattle) at the animal category level, including references to the sources of information. However, the information is provided for two provinces only (Quebec and Saskatchewan). During the review, the Party explained that efforts to improve the transparency of reporting across the agriculture sector are ongoing, which will make data and information on the collection of data more widely available, as described in ID# A.2 above. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet included in the NIR quantitative and qualitative information on all parameters used for the estimation of enteric fermentation for every province in the country; (c) Not resolved. No information on the protocol for collecting parameters and revising estimates by region and animal type was provided in the NIR. During the review, the Party explained that efforts to improve the transparency of reporting across the sector are ongoing.
A.7	3.A.4 Other livestock – CH_4 (A.8, 2021) (A.15, 2019) Accuracy	Estimate the enteric fermentation EF for llamas and alpacas on the basis of the proportion of llamas to alpacas (using statistics or expert judgment), using the EF for alpacas from table 10.10 of the 2006 IPCC Guidelines (vol. 4) and estimating an approximate EF for llamas on the basis of the EF for alpacas and the weight of llamas.	Resolved. The Party continued to report combined emissions from camelid enteric fermentation, which includes llamas and alpacas, using the tier 1 approach in CRF table 3.As1. During the review, the Party clarified that it considers it more accurate to estimate emissions for llamas and alpacas combined than in a disaggregated manner. The ERT agrees with this assessment as the country has not separated AD for the llama and alpaca populations and as the default EF for enteric fermentation in the 2006 IPCC Guidelines (vol. 4, chap. 10, table 10.10) provided for camelids is for alpacas and there is no provision for the direct calculation and reporting on llamas and alpacas separately. In addition, emissions from enteric fermentation from llamas and alpacas (reported under the camels subcategory in CRF table 3.As1) is not a key category for Canada, and the magnitude of the CH_4 emissions for this subcategory (0.10 kt CH_4 in 2021; i.e. 2.5 kt CO_2 eq) is below the threshold of significance established in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines (0.05 per cent of national total emissions excluding LULUCF for the latest reported year (i.e. 335.31 kt CO_2 eq for Canada's 2023 submission) and not exceeding 500 kt CO_2 eq).
A.8	3.B Manure management – CH_4 and N_2O (A.9, 2021) (A.2, 2019) (A.3, 2017) (A.12, 2016) Transparency	Provide in the NIR the reasons why emissions from anaerobic lagoon and daily spread have not been estimated, in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines.	Not resolved. The Party reported emissions from dairy cattle, non-dairy cattle, sheep and lambs, swine, buffalo, camels, goats, horses and poultry as "NE" for daily spread and anaerobic lagoon MMS in CRF table 3.B(a)s2. The Party clarified in the NIR (part 2, section A3.4.3.3, p.116) that anaerobic treatment lagoons and daily spread are not typically used for manure storage in Canada and that these types of system were not identified in the expert consultation carried out by Marinier, Clark and

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			Wagner-Riddle (2005) or in farm environmental management surveys, which are the sources of animal waste management system allocation data for Canada. During the review, the Party explained that dairy cattle and swine contribute the majority of manure VS stored in liquid systems in Canada. Canada estimates that in order to reach the significance threshold established in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines, dairy cattle or swine manure from approximately 300 to 500 farms would need to be allocated entirely to uncovered anaerobic treatment lagoons, based on an MCF value of 0.70. Owing to the low MCF factor associated with daily spread (0.001), it would not be possible to reach the significance threshold for dairy cattle or swine with the current livestock populations in Canada. On the basis of this analysis, the Party considers that it is highly unlikely that manure from Canadian livestock would be managed with anaerobic lagoons or daily spread in sufficient quantities to reach the significance threshold established in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines (0.05 per cent of national total emissions excluding LULUCF for the latest reported year (i.e. 335.31 kt CO_2 eq for Canada's 2023 submission) and not exceeding 500 kt CO_2 eq). The ERT agrees with the analysis. In addition, Canada explained that it plans to review, in consultation with regional experts, the use of "NE" to report emissions for livestock other than dairy cattle and swine for the 2024 submission. The ERT considers that the recommendation has not yet been addressed because Canada continues to use "NE" to report emissions from MMS anaerobic lagoons and daily spread for dairy cattle, non-dairy cattle, swine, sheep and lambs, buffalo, camels, goats, horses and poultry, but the Party has not provided in the NIR the justification that the likely level of emissions is below the threshold of significance established in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines. Furthermore, the ERT noted an inconsistency between the NIR (part 1, p.116), in which the information suggests the emissions and AD should be reported as "NO", and the CRF tables, in which the emissions are reported as "NE".

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A.9	3.B Manure management – CH_4 (A.10, 2021) (A.16, 2019) Accuracy	Construct a time series of average temperatures for each region for 1990–2017 and use MCFs for all animals on the basis of those average annual temperatures and in line with the 2006 IPCC Guidelines (i.e. using the 10 °C value if the average annual temperature is below 10 °C).	Not resolved. The Party did not construct a time series of average temperatures for each region for 1990–2021 and use MCFs for all animals on the basis of those average annual temperatures and in line with the 2006 IPCC Guidelines (vol. 4, chap. 10.4.2, p.10.44–10.50.). During the review, the Party clarified that it plans to implement the approach in the 2019 Refinement to the 2006 IPCC Guidelines (vol. 4, chap. 10.4), which uses monthly temperatures and retention time as predictors of CH_4 loss rather than an annual average, and that this action is already included in the inventory improvement plan (NIR part 1, section 8.3, p.237). The ERT considers that the recommendation has not yet been addressed because the Party has not yet constructed a time series of annual average temperatures for the 1990–2021 time series for each region and used MCFs on the basis of those average annual temperatures and in line with the 2006 IPCC Guidelines or implemented the methodology from the 2019 Refinement to the 2006 IPCC Guidelines, justifying how it better reflects the Party's national circumstances.
A.10	3.B Manure management – N_2O (A.24, 2021) Accuracy	Correct the error in calculations and report correct Nex data for deer, mules and asses, and buffalo for all relevant years of the time series.	Resolved. The Party reported Nex rates for deer (13.58 kg N/head/year) and mules and asses (26.83 kg N/head/year) in CRF table 3.B(b). The ERT agreed with these estimations. For buffalo, the value reported by Canada (67.57 kg N/head/year) was slightly lower than that estimated by the ERT on the basis of the data contained in NIR table A3.4-25 (part 2, p.126) (67.74 kg N/head/year), which resulted in a lower total N excreted estimation in Canada's submission (10,104,170.78 kg N) than the ERT estimation (10,130,370 kg N). During the review, the Party clarified that for the calculations reported in CRF table 3.B(b) it used the unrounded animal weight (578.5 kg/animal), while in NIR table A3.4-25 it reported the rounded figure (580 kg/animal). The ERT verified the estimations and agreed with the Party that the differences found for Nex and total N excreted from buffalos were due to the differences in the animal weight values reported in NIR table A3.4-25 and CRF table 3.B(b). The ERT considers that the recommendation has been addressed, as the exact Nex value was included in the CRF table and used for the calculations, although an inconsistency between the NIR and the CRF table was found (see ID# A.18 in table 5).
A.11	3.B.3 Swine – CH_4 (A.12, 2021) (A.19, 2019) Transparency	(a) Provide in the NIR a detailed description of the methodologies used in estimating the VS of swine, as well as the values of the parameters by subcategory and region (i.e. weight, weight gain, VS and any other parameter used) and explicit references to the sources of data (i.e. document, page, table, row and column);	(a) Addressing. The Party reported in its NIR that the mean VS for swine and each of its subcategories is estimated at the provincial level (part 2, section A3.4.3.1, p.113). The NIR includes a description of the methodology and underlying assumptions used for estimating DE (NIR table A3.4-15, p.114), dry matter intake (NIR table A3.4-16, p.115) and ash content in manure (NIR table A3.4-17, p.115), including references to the source of the data. However, the ERT considers that the recommendation has not yet been fully addressed as the information on DE, dry matter intake and ash content

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		(b) Where assumptions for the selection of the parameters are used, provide detailed information on the assumptions in line with the protocol for expert elicitation included in the 2006 IPCC Guidelines (vol. 1, annex 2A.1, chap. 2).	of manure has not been provided by province and animal subcategory in the NIR. During the review, the Party explained that actions are under way to increase the transparency of the inventory (see ID# A.2 above); (b) Resolved. The Party reported in its NIR (part 2, section A3.4.3.1, p.114) the general assumptions made for determining DE for sheep, horses and swine associated with different proportions of forage and grain in the animals' diet in different provinces. The NIR also noted that the dry matter intake for non-cattle animal categories was determined by consultation with experts and from published values.
A.12	3.B.3 Swine – N_2O (A.13, 2021) (A.18, 2019) Accuracy	Correct the estimates of the Nex rate of market swine by using the appropriate value for market swine given in table 10.19 of the 2006 IPCC Guidelines (vol. 4) or provide documented and supported information for the assumptions regarding the erroneous values proposed in table 10.19 of the 2006 IPCC Guidelines.	Resolved. The Party recalculated the entire time series for Nex and reported a Nex rate for swine of 7.73 kg N/head/year in CRF table 3.B(b). In the NIR (part 2, p.124), the Party explained that distinct parameters were used to estimate Nex for subcategories of breeding animals and market animals. For market swine, increases in growth rates and live weights were used to develop a country-specific time series of animal mass per production stage, which was then multiplied by the default Nex rate from table 10.19 in the 2006 IPCC Guidelines (vol. 4, chap. 10). For breeding animals, the default Nex rate was multiplied by the default animal mass (198 kg) from the 2006 IPCC Guidelines (vol. 4, chap. 10.A.2). During the review, Canada explained that it estimates Nex rate for five subcategories of swine using a country-specific time series of typical animal mass (NIR table A3.4-24, part 2), and that the Nex rate was estimated for each of Canada's 10 provinces, weighted by the proportion of animals of each subcategory in a province relative to the national total swine population, to arrive at a time series of weighted national Nex rates reported under swine in the CRF tables. The Party also provided an Excel file with the parameters used in the calculation. The ERT agreed with the weighed estimated Nex rate for swine.
A.13	3.B.5 Indirect N_2O emissions – N_2O (A.16, 2021) (A.6, 2019) (A.15, 2017) Accuracy	Estimate indirect N_2O emissions from MMS due to leaching and run-off by using a tier 2 approach and by developing the value of $Frac_{leachMS}$ on the basis of country-specific data on N run-off and leaching from MMS.	Not resolved. The Party identified indirect N_2O emissions for this category as key (NIR table A1-2, part 2). The Party reported in its NIR (part 1, section 5.3.3.2, p.158) that indirect N_2O emissions from MMS due to leaching and run-off for cattle and swine are estimated using a country-specific model, and that leaching losses for other livestock categories are not estimated given that no country-specific leaching loss factors are available. During the review, the Party clarified that efforts to address this issue are ongoing. The Party noted that this is a low priority improvement relative to other improvements that are expected to have a more significant impact on emissions. In addition, the Party explained that it is exploring the methodologies available in the 2019 Refinement to the 2006 IPCC Guidelines. The ERT considers that the recommendation has not yet been addressed because the Party has not yet included estimations of indirect N_2O emissions from MMS due to

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			leaching and run-off for sheep and other animal livestock categories using the tier 2 approach.
A.14	3.B.5 Indirect N_2O emissions – N_2O (A.18, 2021) (A.20, 2019) Accuracy	Estimate the percentage of managed manure N for the livestock category that volatilizes as NH_3 and NO_X taking into account the volatilization of both NH_3 and NO_X in line with the 2006 IPCC Guidelines.	Resolved. The Party reported in its NIR (part 1, section 5.3.3.2, p.156) and CRF table 3.B(b) indirect N_2O emissions from NH_3 and NO_X volatilization. For dairy cattle and swine, the amount of manure N subject to loss volatilization of NH_3 and NO_X during storage is estimated using a revised version of the Canadian NH_3 emission model to generate ecoregion-specific N loss factors by animal type and MMS. Thus, total NH_3 and NO_X losses were 8, 17 and 24 per cent for liquid, solid and other MMS for dairy cattle respectively in 2021 (NIR table A3.4-28, part 2, p.129) and 18 and 23 per cent for liquid and solid MMS for swine respectively in 2021 (NIR table A3.4-29, part 2, p.129). This is in line with the default values in the 2006 IPCC Guidelines (vol. 4, chap. 10.5.1, pp.10.56–10.58). For all other livestock categories, the amount of manure N subject to losses from volatilization of NH_3 during storage is calculated for each animal type and MMS using default values provided in the 2006 IPCC Guidelines (vol. 4, chap. 10.5.1, table 10.22, p.10.70). The EFs for N_2O from volatilization during manure storage and handling in dry and wet climates are taken from the 2019 Refinement to the 2006 IPCC Guidelines (vol. 4, chap. 11.2.2.2).
A.15	3.D Direct and indirect N_2O emissions from agricultural soils – N_2O (A.19, 2021) (A.8, 2019) (A.6, 2017) (A.9, 2016) (A.16, 2015) Completeness	Report direct N_2O emissions from sewage sludge and other organic fertilizers applied to soils.	Addressing. The Party reported in its NIR (part 2, section A3.4.5.1, p.133) and in CRF table 3.D emissions from biosolids (i.e. sewage sludge) applied to agricultural soils, indicating that 21,550,622 kg N was applied to soils in 2021. However, emissions from compost applied to soils (i.e. other organic fertilizers) were reported as "NE". During the review, the Party clarified that efforts are being made to develop a country-specific N_2O EF that will allow the estimation of emissions from compost applied to soils. The ERT confirmed that this action is included in the inventory improvement plan reported in NIR table 8.5 (part 1). The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet included N_2O emissions from compost under category 3.D.
A.16	3.D.b Indirect N_2O emissions from managed soils – N_2O (A.20, 2021) (A.9, 2019) (A.7, 2017) (A.15, 2016) Completeness	When estimating direct N_2O emissions from application of sewage sludge and other organic fertilizers to soils, also estimate the related indirect N_2O emissions.	Addressing. The Party reported category 3.D indirect N_2O emissions associated with the application of sewage sludge to agricultural soils (i.e. biosolids) in CRF table 3.D. However, direct and indirect emissions from compost applied to soils (i.e. other organic fertilizers in the CRF tables) were not reported. During the review, the Party clarified that efforts are being made to estimate emissions, including indirect N_2O emissions, from compost applied to soils (see ID# A.15 above).

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			The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet estimated indirect N_2O emissions from compost fertilizer applied to soils.
A.17	3.G Liming – CO_2 (A.22, 2021) (A.21, 2019) Comparability	(a) Develop the underlying AD time series for limestone and dolomite, for example by using the ratio of limestone to dolomite used to calculate the weighted EF, and use the corresponding IPCC default EFs separately for limestone and dolomite, as specified in the 2006 IPCC Guidelines (vol. 4, chap. 11.3.2); (b) Report separately the emissions from limestone and dolomite assumed to be applied to soils in CRF table 3.G-I.	(a) Addressing. The Party reported in its NIR (part 2, section A3.8.4.1, p.152) that the underlying AD time series for limestone and dolomite was developed using the limestone and dolomite ratio for 1990–2006 in Natural Resources Canada's *Canadian Minerals Yearbook*, and, for later years, using data requested by the inventory team. Estimations were carried out using the tier 1 approach and the corresponding default EFs from the 2006 IPCC Guidelines (vol. 4, chap. 11.3.2, p.11.31). However, the Party did not include in the NIR detailed information on the limestone and dolomite ratio used to estimate the time series AD for the country. During the review, the Party clarified that the ratio used was constant for the time series and was based on information provided by the Canadian Fertilizer Institute; (b) Resolved. The Party reported emissions from limestone and dolomite (e.g. 127.44 kt CO_2 and 43.70 kt CO_2 for 2021 for limestone and dolomite respectively) separately in CRF table 3.G-I (see also ID# A.19 in table 5).
LULUCF			
L.1	4. General (LULUCF) (L.1, 2021) (L.1, 2019) (L.1, 2017) (L.2, 2016) (L.4, 2015) (59, 2014) (9 and 63, 2013) Completeness	Improve the completeness of reporting of the pools in all mandatory categories currently reported as "NE" and include a description of how the notation keys have been used.	Addressing. The Party reported in its NIR that significant efforts to resolve the completeness issues are still under way and several data-collection and research multi-year projects are being carried out to address these issues. These ongoing improvements are briefly described in the NIR (part 1, section 6.1, p.175, and section 8.3.1, p.230; the recalculations are presented in NIR table 8-5). Nevertheless, the ERT still identified subcategory–pool combinations for which the Party reports "NE" (or other notation keys, where the notation key used is inconsistent with IPCC good practice, e.g. the use of "NO" when the tier 1 methodology requires an estimate to be provided) despite the provision of tier 1 or higher methods in the 2006 IPCC Guidelines and the reporting of respective AD by the Party. The list below includes all cases of notation keys used for categories and carbon pools in CRF tables 4.A–4.F in which respective AD are occurring (or are included elsewhere) and for which the 2006 IPCC Guidelines provide a tier 1 or higher method for estimating their change: (a) Table 4.B – the pool "biomass: gains" of forest land converted to cropland is reported as "NO"; (b) Table 4.B – the pool "organic soils" of forest land converted to cropland is reported as "IE"; (c) Table 4.B – the pool "biomass: gains" of grassland converted to cropland is reported as "NO"; (d) Table 4.B – the pool "biomass: losses" of grassland converted to cropland is reported as "NO";

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			(e) Table 4.B – the pool "biomass: net change" of grassland converted to cropland is reported as "NO"; (f) Table 4.B – the pool "organic soils" of grassland converted to cropland is reported as "IE"; (g) Table 4.C – the pool "mineral soils" of grassland remaining grassland is reported as "NE"; (h) Table 4.D – the pool "biomass: gain" of land converted to peat extraction is reported as "NO"; (i) Table 4.D – the pool "biomass: losses" of land converted to peat extraction is reported as "NO, IE"; (j) Table 4.D – the pool "biomass: net change" of land converted to peat extraction is reported as "NO, IE"; (k) Table 4.D – the pool "biomass: gain" of other land converted to flooded land is reported as "NO"; (l) Table 4.D – the pool "biomass: losses" of other land converted to flooded land is reported as "NO"; (m) Table 4.D – the pool "biomass: net change" of other land converted to flooded land is reported as "NO"; (n) Table 4.E – the pool "organic soils" of settlements remaining settlements is reported as "NE"; (o) Table 4.E – the pool "biomass: gain" of forest land converted to settlements is reported as "NO"; (p) the pool "organic soils" of forest land converted to settlements is reported as "IE"; (q) Table 4.E – the pool "biomass: gain" of cropland converted to settlements is reported as "NE"; (r) Table 4.E – the pool "biomass: losses" of cropland converted to settlements is reported as "NE"; (s) Table 4.E – the pool "biomass: net change" of cropland converted to settlements is reported as "NE"; (t) Table 4.E – the pool "mineral soils" of cropland converted to settlements is reported as "NE"; (u) Table 4.E – the pool "organic soils" of cropland converted to settlements is reported as "NE"; (v) Table 4.E – the pool "biomass: gain" of grassland converted to settlements is reported as "NO"; (w) Table 4.E – the pool "mineral soils" of grassland converted to settlements is reported as "NE"; (x) Table 4.E – the pool "organic soils" of grassland converted to settlements is reported as "NE". Issues with the incorrect use of notation keys in CRF tables 4(III), 4(IV) and 4.Gs1 for pools or emissions where the activity occurs and the 2006 IPCC Guidelines

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			provide default methodologies are included in other findings and are not repeated here. Issues with notation keys with respect to AD and their propagation to the CSC are not addressed here but in other findings on gaps in land representation. During the review, the Party elaborated on the plans for and status of work on developing country-specific methods to fill these gaps. The Party indicated that new personnel have been added to the inventory team in recent years to assist in undertaking these and other planned improvements (e.g. in land representation). The ERT welcomes the ongoing work to develop and implement these planned improvements. Nonetheless, the ERT raised the question of why 2006 IPCC Guidelines default methods are not being applied for mandatory categories while the planned improvements (i.e. developing country-specific methods) are under development. The Party clarified that in many cases there is evidence that the changes in carbon pools in the country would be insignificant, making it extremely difficult to quantify. For example, in certain cases, such as biomass conversion in grassland converted to cropland, in which biomass loss and gain is considered equivalent, on average, depending on the region and the crop type conversion, the application of a tier 1 method would result in large overestimates. In these cases, Canada prioritizes accuracy over completeness. Similarly, the Party clarified that in cases where "IE" is reported, this is often due to a lack of AD, such as for organic soil conversions in all land conversions. Canada is currently unable to quantify areas of organic soil disturbance due to management of remaining lands or land-use conversions for the subcategories 4.A.1, 4.A.2, 4.B.2, 4.C.1, 4.D.1.2, 4.D.2.2, 4.E.1 and 4.E.2. Likewise, estimates of areas of cropland and grassland conversion to settlements would require estimates of subland use or land cover to differentiate, for example, paved land from land with grass cover. In general, the Party expressed concerns about implementing an interim solution that prioritizes completeness over accuracy in reporting while more accurate methods are under development. The use of default values and methods from the 2006 IPCC Guidelines is deemed unsuitable by the Party for its national circumstances and conditions in most cases, but the Party agreed to review past assumptions and if interim solutions are available, it will implement them to improve completeness. The ERT considers that incompleteness always adds a bias to a national GHG inventory given that not estimating and reporting an actual emission or removal is a systematic underestimate of the national total emissions or removals, and thus it cannot be established a priori that a missing estimate is a smaller bias than an estimate estimated using a tier 1 method. The ERT also considers that an estimate estimated using a tier 1 method satisfies the mandatory UNFCCC Annex I inventory reporting guidelines requirements for insignificant source/sink categories or for significant source/sink categories where national circumstances do not allow the use of higher-tier methodologies for preparing the estimates, as the ERT understands is the case for Canada. Finally, the Party can only provide proof of the bias in using tier

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			1 estimates by reporting the respective estimates with country-specific methods, which the Party has not yet done. Thus, the ERT considers that the recommendation has not yet been fully addressed because the Party continues to report "NE" for pools of several mandatory categories, as listed above.
L.2	4. General (LULUCF) (L.2, 2021) (L.2, 2019) (L.2, 2017) (L.3, 2016) (L.13, 2015) Completeness	Improve the completeness of land area representation for the LULUCF sector by amending the reporting (both the land-use change matrix and the estimates for category-specific emissions and removals in the CRF tables) by including all land areas and making it clear which categories and subcategories occur in Canada and whether the emissions/removals are calculated. This includes both managed land areas for which no emissions or removals are expected (e.g. grassland remaining grassland) and unmanaged areas.	Addressing. The Party reported the area of unmanaged forest land in CRF table 4.1; despite this improvement and references to ongoing improvements in land representation (NIR part 1, p.237), the ERT noted that land use areas and land-use changes are not all quantified in CRF table 4.1 and furthermore, some of the quantified land use areas and land-use-change areas are not complete (i.e. the entire areas are not reported). The Party also reported areas of categories other land, unmanaged grassland and unmanaged wetlands as "IE" in the CRF tables; the ERT noted the importance of quantifying and reporting these areas, as conversions of these lands result in emissions/removals (e.g. conversion of unmanaged wetlands (peatlands) to peat extraction, conversion of unmanaged grassland to settlements). The Party further reported (NIR part 1, p.177) that the diversity of the settlements land-use category has so far precluded a complete assessment of its extent in Canada; the ERT noted that an incomplete representation (and, as a result, an inaccurate representation) of managed and unmanaged lands in the land-use change matrices inevitably leads to inter-annual inconsistencies between the land-use change matrices: for a specific year, the initial areas plus the result of all conversions do not equal the final areas (see ID# L.5 below). During the review, the Party elaborated on the plans for and status of the work to fill gaps in the land-use change matrices by developing new methods to monitor land use and conversions that will include, to a large extent, spatially explicit methods and an overall system to integrate all methods. The Party indicated that new personnel have been added to the inventory team in recent years to assist in undertaking these and other planned improvements, such as in land representation. The ERT welcomes the ongoing work to develop and implement these planned improvements. Nonetheless, the ERT raised the question of whether the Party is considering estimating some of the missing land use and land-use change areas using, for example, secondary data sets, as per the 2006 IPCC Guidelines (vol. 4, chap. 3, p.3.17), while the planned improvements are still under development. The Party clarified that it prioritizes accuracy in reporting over completeness and prioritizes improvements that will improve estimates of emissions and removals over using resources to quantify unmanaged land areas that do not contribute to estimates. The Party's position is to prioritize and develop authoritative data on national land use and land-use change. The ERT considers that the recommendation has not yet been fully addressed because the Party's land-use change matrices does not quantify separately areas of categories other land, unmanaged grassland and unmanaged wetlands and does not quantify the full extent of the total settlements area. As a consequence, the land-use

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			change matrix does not quantify all land conversions between unmanaged and managed land-use categories that lead to anthropogenic GHG emissions or removals.
L.3	Land representation (L.4, 2021) (L.4, 2019) (L.4, 2017) (L.16, 2016) Transparency	Specify in the NIR that the total land area is included in the inventory and report the land area in CRF table 4.1 separately for unmanaged forest, unmanaged grassland and unmanaged wetlands.	Resolved. The Party reported areas of unmanaged forest land in CRF table 4.1. Areas of unmanaged grassland and unmanaged wetlands were not reported and are instead represented in the land-use change matrices (CRF table 4.1) with the notation key "IE". However, this issue is already included under ID# L.2 above. The ERT thus considers that this issue is resolved.
L.4	Land representation (L.5, 2021) (L.5, 2019) (L.5, 2017) (L.17, 2016) Transparency	Include in the NIR the correction of the reporting in CRF table 4.1 (to include information on annual changes) as part of the planned improvement, along with any update on the status of implementation of other parts of the ongoing project to revise and improve the consistency and completeness of the land-transition matrix.	Resolved. The Party reported in CRF table 4.1 annual areas of land-use changes, although these changes are limited to some land-use categories, namely forest land converted to cropland, to wetlands and to settlements; cropland converted to forest land and to settlements; grassland converted to cropland and to settlements; and other land converted to wetlands (although the category other land also includes unmanaged forest land, unmanaged grassland and unmanaged wetlands). However, this issue is already included under ID# L.2 above. The ERT thus considers that this issue is resolved.
L.5	Land representation – CO_2, CH_4 and N_2O (L.6, 2021) (L.18, 2019) Consistency	(a) Ensure that, for all years and all land-use categories in the land-use matrix, the values reported for year X–1 in the "final area" row in CRF table 4.1 equal the values reported in year X in the "initial area" column to improve the consistency of the land use and land-use change reported and ensure consistency with the area changes reported in the sectoral background tables; (b) Recalculate the associated emissions and removals, where appropriate; (c) Explain in the NIR the reason for recalculating the associated GHG emissions and removals as a result of the land-transition matrices being revised.	(a–c) Addressing. The Party reported final areas for the managed land categories in CRF table 4.1 that are consistent with the total areas in the CRF background tables 4.A–4.F. However, the Party reported area data in CRF table 4.1 that are inconsistent between years, with the initial areas each year not matching up to the final areas of the previous year. For example, the initial area for 2021 of cropland is 46,258.79 kha, of wetlands is 492.18 kha and of settlements is 991.58 kha, while the final areas for 2020 are reported as 46,386.84 kha, 517.95 kha and 1,028.25 kha respectively. During the review, the Party clarified that it uses a mix of approaches for certain land use and land-use change categories, while others are not estimated at all, resulting in differences between final areas of a given year and the initial areas of the following year. The Party elaborated on the plans for and status of work to fill gaps in the land-use change matrices, including unmanaged lands, by developing new methods to monitor land use and land-use conversions that will include, to a large extent, spatially explicit methods and an overall system to integrate the respective methods. The ERT welcomes the ongoing work to develop and implement these planned improvements. Nonetheless, the ERT raised the question of whether the Party is considering estimating some of the missing land use and land-use change areas using, for example, secondary data sets, as per the 2006 IPCC Guidelines (vol. 4, chap. 3), while the planned improvements are under development. The Party clarified that it prioritizes accuracy in reporting over completeness and prioritizes improvements that will improve estimates of emissions and removals over using resources to quantify unmanaged land areas that do not contribute to emission estimates. The Party's position is to prioritize and develop authoritative data on national land use and land-use change.

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			The ERT considers that the recommendation has not yet been addressed because the initial areas given in the annual land-use change matrices in CRF table 4.1 do not match the final areas in the land-use change matrices of the respective previous years. Consequently, the overall certainty of land area data reported cannot be assessed with accuracy and the reported uncertainty analysis is to be considered as affected by a bias given the inconsistency of the time-series data. The ERT acknowledges that emissions and removals from unmanaged lands are not considered anthropogenic; however, quantifying these lands inaccurately, in particular if there were conversions from unmanaged lands to managed lands, reduces the confidence in estimates of anthropogenic emissions and removals from the LULUCF sector and would lead to biases. Finally, the ERT considers that the completion of the land representation improvements should be prioritized ahead of all other planned improvements for the sector.
L.6	4.A.1 Forest land remaining forest land – CO_2 (L.9, 2021) (L.19, 2019) Transparency	(a) Document the justification for the assumption that all emissions and subsequent removals due to stand-replacing fires in managed forest land are not anthropogenic; (b) Include information on how these non-anthropogenic circumstances, which are the source of significant emissions, are beyond the control of, and not materially influenced by, the country, and tend to average out across time, as described in the managed land proxy definition.	(a–b) Resolved. The Party reported information in the NIR (e.g. part 2, pp.160, 180–181; part 2, annex 3, p.161) on the method applied to disaggregate emissions and subsequent removals from natural disturbances. From a transparency perspective, the information provided by the Party supports its assumption that emissions and removals of this natural disturbance component are not anthropogenic, and that the approach used by the Party ensures that natural disturbance emissions and subsequent removals average out across time and space, as described in the managed land proxy. However, the ERT considers that the method applied by the Party does not ensure an accurate disaggregation and thus raised a new issue (see ID# L.22 in table 5).
L.7	4.A.1 Forest land remaining forest land – CO_2 (L.10, 2021) (L.20, 2019) Transparency	(a) Improve the transparency of the reporting by further disaggregating the AD on each forest land subdivision in CRF table 4.A with a row for forest land not affected by natural disturbance and a row for forest land affected by natural disturbance; (b) Include in the NIR a land-use matrix that shows the annual changes in areas of forest land that qualify as being subject to natural disturbances, together with a table containing their emissions and removals.	(a) Resolved. The Party reported in CRF table 4.A, for each year of the time series, subdivisions of forest land remaining forest land that are considered anthropogenic, for which emissions and removals are reported, and subdivisions that are considered under the natural disturbance component, for which only the areas are reported. The ERT noted that that these two components are further subdivided between Canada's 18 reporting zones; (b) Addressing. The Party reported in NIR table 6-4 (part 1) the area of managed forest land subject to natural disturbances, but only for 2021. During the review, the Party explained that transparency can be enhanced further by providing public access to the land-use matrices for the full time series through a weblink in the NIR. The ERT agrees with the Party. The ERT considers that this recommendation has not yet been fully addressed because the Party has not yet reported in the NIR a complete time series of the annual total areas separately for the anthropogenic and natural disturbance components of forest land and, importantly, the annual conversions between the two components. Complete tracking of these areas is needed to ensure transparency of reporting on natural disturbances.

ID#	*Issue classification*[a, b]	*Recommendation from previous review report*	*ERT assessment and rationale*
L.8	4.A.2 Land converted to forest land – CO_2 (L.12, 2021) (L.9, 2019) (L.8, 2017) (L.7, 2016) (L.19, 2015) Accuracy	(a) Provide additional information on why using zero for annual area conversions to forest land for 2009–2013 is considered reasonable compared with alternative ways to construct the time series; (b) Continue with efforts to acquire the missing AD for land converted to forest land.	(a) Resolved. The Party reported in CRF table 4.1 areas of cropland converted to forest land in each year for 2009–2013 rather than reporting those areas as zero; (b) Resolved. The Party continued to rely on official statistics on afforestation from the provinces and territories, which are not updated annually (NIR part 1, pp.186–187). The Party nonetheless continued with efforts to obtain more complete and up-to-date data for recent years.
L.9	4.A.2.1 Cropland converted to forest land – CO_2 (L.13, 2021) (L.10, 2019) (L.17, 2017) Completeness	(a) Include the loss of the biomass in cropland in the CSC in living biomass due to conversion of cropland to forest land for all types of cropland, including abandoned cropland; (b) If the biomass losses are already accounted for under cropland in the Century model, transparently document in the NIR how they are already accounted for.	(a–b) Addressing. The Party reported estimates of biomass carbon stock gain and carbon stock losses in cropland converted to forest land in CRF table 4.A. However, it did not report (1) carbon stock losses associated with the loss of the resident average annual crop biomass before conversion to forest land or (2) CSCs in abandoned cropland converted to forest land. During the review, regarding issue (1) above, the Party clarified that biomass and DOM carbon pools are considered empty prior to the establishment of plantations. Regarding issue (2) above, the Party clarified that, for natural conversion (i.e. a successional change in vegetation), remote sensing based methodological approaches are under development to monitor this natural process but, at present, they are not adequately refined to produce results that would provide sound estimates of CSC throughout the complete time series. In the absence of operational methodologies to estimate natural forest establishment on abandoned land, Canada cannot currently develop reliable estimates for this process. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet included the biomass carbon stock losses in cropland in the year of conversion to forest land, including from abandoned cropland converted to forest land. The ERT notes that the 2006 IPCC Guidelines (vol. 4, chap. 2, equation 2.16) provide a method and default factors to make such an estimate.
L.10	4.A.2.1 Cropland converted to forest land – CO_2 (L.14, 2021) (L.22, 2019) Accuracy	(a) Report carbon losses due to the conversion of cropland to forest land applying at least a tier 2 methodology using default values provided in the 2006 IPCC Guidelines for biomass in annual cropland for years when cropland is converted to forest land; (b) If the analysis demonstrates that the likely level of emissions meets the criteria in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines, use the notation key "NE", and, for years when conversion did not occur, if emissions or removals did not occur in those pools, report them as "NA".	(a–b) Resolved. The Party reported estimates of biomass CSCs in cropland converted to forest land in CRF table 4.A and reported in the NIR (part 2, annex 3, section A3.5.2.7, p.162) information on the method applied to estimate CSCs in cropland converted to forest land in its tier 3 model. While losses of biomass in the year of conversion are not included in the estimate, the recommendation to address this issue is already included in ID# L.9 above.

ID#	*Issue classification*[a, b]	*Recommendation from previous review report*	*ERT assessment and rationale*
L.11	4(III) Direct N_2O emissions from N mineralization/immobilization and 4(IV) indirect N_2O emissions from managed soils – N_2O (L.18, 2021) (L.13, 2019) (L.10, 2017) (L.10, 2016) (L.24, 2015) Completeness	(a) Estimate all the direct N_2O emissions as well as the associated indirect N_2O emissions from N mineralization or immobilization associated with loss or gain of soil organic matter; (b) Until the estimation is implemented, provide information on the planned improvement and assessment of the quantitative impact of this missing category in accordance with the provisions in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines.	(a–b) Addressing. The Party reported estimates of direct N_2O emissions from N mineralization/immobilization only for land converted to cropland in CRF table 4(III). The Party explained in NIR table A5-1 (part 2, annex 5, p.248) that N_2O emissions from grassland and settlements were not estimated and that emissions from forest land were not reported because they are considered to be insignificant. The Party reported in its NIR (part 1, section 6.3.1.2, p.183) that the likely level of emissions for forest land ranges from zero to 55 kt CO_2 eq, lower than the significance threshold established in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines. During the review, the Party provided the ERT with complete emission estimates for forest land, that is, both direct N_2O emissions from N mineralization/immobilization and indirect N_2O emissions from managed soils. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet provided estimates for direct and indirect N_2O emissions from grassland and settlements.
L.12	4.G HWP – CO_2 (L.19, 2021) (L.16, 2019) (L.13, 2017) (L.13, 2016) (L.22, 2015) Transparency	Include data for 1900–1940 for estimating emissions for the category HWP, as part of the improvement work in relation to the category and consider how the uncertainty may be affected.	Resolved. The Party reported in its NIR (part 2, annex 3, section A3.5.3, p.170) that data for 1900–1940 have been added through back-calculating production data for 1941–1989. Information on the assumed impact on the overall uncertainty of the category was not provided in the NIR. However, this issue is addressed in ID# L.13 below.
L.13	4.G HWP – CO_2 (L.21, 2021) (L.24, 2019) Transparency	Include in the NIR a clear explanation of the assumptions and methods applied for estimating emissions from HWP for 1900–1940.	Addressing. The Party reported in its NIR (part 2, annex 3, section A3.5.3, p.170) that data for 1900–1940 have been added through back-calculating production data for 1941–1989. However, information on the methodology applied for back-calculating or on the assumed impact of such an addition to the overall uncertainty of the category was not provided. During the review, the Party provided information on the back-calculating method from 1940 back to 1900 and noted that the next submission will contain more information on the assumed trends that were used. The ERT noted that the assumed impact of back-calculating for 1900–1940 on the overall uncertainty of the HWP category is likely to be insignificant for the reported time series for 1990 onward. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet reported in its NIR details on the methodology and assumptions applied for back-calculating and how this back-calculating step is reflected in the uncertainty analysis.
L.14	4.G HWP – CO_2 (L.22, 2021) (L.25, 2019) Transparency	(a) Improve the transparency of the reporting by including in the NIR the explanation and clarifications of the treatment of firewood in the HWP model provided during the review;	(a) Resolved. The Party reported in NIR figure A3.5-8 (part 2) a simplified schematic diagram of carbon flows in HWP, in which it is shown that firewood does not enter any of the HWP product pools and thus its carbon content is converted to CO_2 emissions in the year in which it is harvested;

ID#	*Issue classification*[a, b]	*Recommendation from previous review report*	*ERT assessment and rationale*
		(b) Include information on the amount of wood chips and pellets exported and revise the emission estimates, if needed, when new information on sources and volumes of firewood produced becomes available.	(b) Resolved. The Party reported in its NIR (part 2, annex 3, section A3.5.3, p.170) that the export of wood chips/pellets is currently not considered in the model. The ERT noted that the loss of this carbon is nonetheless included elsewhere in the HWP losses. During the review, the Party clarified and demonstrated that these exported wood products, while not addressed separately, are nonetheless included in the annual HWP contribution calculated by the HWP model. The ERT concludes that the further disaggregation of this subpool does not affect the total net HWP balance. Nevertheless, the ERT suggests that the Party report in its NIR information on exported chips and wood pellets to further enhance the transparency of the submission.
Waste			
W.1	5.A.1 Managed waste disposal sites – CH_4 (W.3, 2021) (W.14, 2019) Accuracy	Either provide in the NIR additional information that supports the assumption that biogenic carbon from rubber and leather would degrade at disposal sites or include the estimated DOC of rubber and leather in the first-order decay model used for calculating CH_4 emissions from landfills.	Resolved. The Party reported in NIR table A3.6-1 (part 2, p.208) DOC and DOC_f values used for calculating all fractions of MSW, including rubber and leather. The 2006 IPCC Guidelines (vol. 5, chap. 2.3.1, footnote 5 to table 2.4, p.2.14) are referred to as the source of the DOC_f value of 0 for rubber. The DOC_f value of 0.1 for leather is now clearly cited as an Environment and Climate Change Canada estimate based on the 2019 Refinement to the 2006 IPCC Guidelines value for less decomposable wastes (vol. 5, chap. 3.2.3, footnote 1 to table 3.0, p.3.12). The ERT considers this approach appropriate given the lack of a specific IPCC default DOC_f value for leather.
W.2	5.A.2 Unmanaged waste disposal sites – CH_4 (W.4, 2021) (W.15, 2019) Accuracy	Either provide in the NIR a justification for applying the default OX for well-managed SWDS together with the default CH_4 correction factor for unmanaged SWDS or use the default value of OX (0) for unmanaged waste disposal sites.	Resolved. The Party reported in NIR table A3.6-9 (part 2, p.218) that it now applies an updated OX value (0) for unmanaged SWDS that receive waste from industrial solid wood waste industries, in line with the 2006 IPCC Guidelines default value for unmanaged SWDS (vol. 5, chap. 3, p.15). The Party has retained its OX value of 0.1 for managed SWDS in the pulp and paper industry based on an Environment and Climate Change Canada commissioned study on the management practices of industrial wood waste in the Canadian pulp and paper industry. The study found that those landfills typically compact, level and dewater residual waste.
W.3	5.C.1 Waste incineration – CO_2, CH_4 and N_2O (W.12, 2021) Convention reporting adherence	(a) Explore the cause of the inconsistencies in the amounts of incinerated MSW reported in the NIR and CRF table 5.C, confirm that the correct and accurate data are used for calculations and report these amounts consistently in the NIR and CRF table 5.C; (b) If necessary, revise the corresponding emission estimates.	(a–b) Resolved. The Party reported in NIR table A3.6-10 (part 2, p.222) and CRF table 5.C consistent values for the amounts of incinerated MSW.
W.4	5.D Wastewater treatment and discharge – CH_4	Include the total organic product in CRF table 5.D for both municipal and industrial wastewater.	Addressing. The Party reported the AD for total organic product for domestic wastewater in CRF table 5.D. For industrial wastewater, the Party revised its AD reporting of total organic product from "NA" to "NE".

ID#	*Issue classification*[a, b]	*Recommendation from previous review report*	*ERT assessment and rationale*
	(W.6, 2021) (W.17, 2019) Transparency		During the review, the Party clarified that CH_4 emissions from industrial wastewater treatment are reported by facilities through the Greenhouse Gas Reporting Program. The Greenhouse Gas Reporting Program for the waste sector covers emissions but not AD related to organic product. While Environment and Climate Change Canada conducts a voluntary survey of biogas CH_4 recovery from industrial wastewater treatment, this survey is limited in scope (to facilities with CH_4 recovery) and does not include sufficient information to extrapolate organic product across all industrial wastewater treatment. The Party stated that it will include an explanation for reporting the total organic product for industrial wastewater as "NE" in its next NIR. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet described in its NIR why it has been unable to include the total organic product for industrial wastewater in its reporting in CRF table 5.D.
W.5	5.D Wastewater treatment and discharge – N_2O (W.7, 2021) (W.18, 2019) Comparability	Report in CRF table 5.D the value used for the fraction of N in protein.	Resolved. The Party reported in CRF table 5.D (additional information boxes) the fraction of N in protein as 0.16, which is the default value in the 2006 IPCC Guidelines (vol. 5, chap. 6, p.25).
W.6	5.D.2 Industrial wastewater – CH_4 (W.10, 2021) (W.22, 2019) Convention reporting adherence	Include the amount of CH_4 flared in CRF table 5.D, replacing "NO" with values where relevant.	Resolved. The Party reported in CRF table 5.D the amount of CH_4 flared from industrial wastewater facilities (2.25 kt CH_4 in 1990, 6.75 kt CH_4 in 2021). The Party described in its NIR (part 1, p.220) how data have been acquired from facility-level surveys, the latest of which was conducted in 2022.
W.7	5.D.2 Industrial wastewater – CH_4 and N_2O (W.11, 2021) (W.23, 2019) Completeness	(a) Report updated information on sewage sludge gas used for energy recovery and the resulting CH_4 emissions as soon as it becomes available; (b) Ensure that all biogas reported for energy recovery in the waste sector is included under the energy sector.	(a) Resolved. The Party reported in CRF table 5.D updated amounts of CH_4 recovered from industrial wastewater facilities (0.14 kt CH_4 in 1990, 8.07 kt CH_4 in 2021). The Party described in its NIR (part 1, p.220) how data have been acquired from facility-level surveys, the latest of which was conducted in 2022. Canada now reports a complete time series for CH_4 recovery from industrial wastewater beyond 2015, which is the point at which the 2021 inventory assumed constant data for the succeeding years. Gap filling of survey data is applied using linear interpolation where necessary (NIR part 2, p.240); (b) Addressing. In the NIR (part 2, p.240) the Party did not explain how emissions (potentially of CO_2, CH_4 and N_2O) from the onward use/combustion of recovered CH_4 from sewage sludge are accounted for in its CRF reporting. The ERT noted that any CO_2 is of biogenic origin and would therefore not be included in national total. However, any CH_4 and N_2O emissions would have to be reported under the energy sector to be included in the national total. During the review, the Party explained that emissions from biogas reported for energy recovery were included under the waste sector, not the energy sector, in the 2023 submission. As a result, CH_4 and N_2O

ID#	Issue classification[a, b]	Recommendation from previous review report	ERT assessment and rationale
			emissions are not included in the national total. The Party indicated that these emissions will be reported under the energy sector in its future submissions. The ERT suggested that the Party clarifies its reporting of all relevant GHG emissions from the onward use/combustion of recovered CH_4 at industrial wastewater facilities in its future NIR submissions.
W.8	5.D.1 Domestic wastewater – CH_4 (W.13, 2021) Transparency	(a) Complete the planned improvement to determine the extent to which CH_4 recovered from wastewater treatment and anaerobic digestion of sludge at wastewater treatment plants is used for energy purposes; (b) If it can be ascertained that the recovery of CH_4 for energy use from these sources occurs in the country, report the amounts of CH_4 recovered for energy from domestic wastewater for the applicable years, ensuring consistency with the reporting in the energy sector; (c) Include in the NIR detailed information on this issue.	(a) Resolved. The Party reported in its NIR figure 7-2 (part 1, p.219) updated data on the amount of CH_4 recovered from anaerobic digestion of sludge at domestic wastewater treatment plants. Emission estimates were recalculated (see (b) below). During the review, the Party clarified that a voluntary survey was conducted to gather data on CH_4 recovery from wastewater treatment and anaerobic digestion of sludge at wastewater treatment facilities. The survey clarified the CH_4 recovery for energy purposes, both from the wastewater treatment process and from anaerobic digestion of wastewater sludge. For facilities that did not respond to the survey, an assumption of no recovery from domestic wastewater treatment, and recovery by flaring only for industrial wastewater treatment and for anaerobic digestion of sludge, was applied; (b) Resolved. The Party reported in CRF table 5.D updated amounts of CH_4 recovered from domestic wastewater facilities (21.53 kt CH_4 in 1990, 36.46 kt CH_4 in 2021). During the review, the Party clarified that these data are now used for estimating CH_4 recovery for energy and that these quantities are included under the energy sector; (c) Addressing. During the review, the Party referred the ERT to its NIR (part 2, p.235) for the methodology for estimating CH_4 recovery from anaerobic digestion of sludge at domestic wastewater treatment plants. However, the ERT noted that the subsection "Methane recovery" does not contain detailed information on the methodology for estimating CH_4 recovery from wastewater treatment in Canada. Specifically, in NIR part 2, equation A3.6-26 does not include a step for CH_4 that is recovered for energy. In addition, no comment was provided on the allocation and reporting of emissions for this source between the waste and energy sectors in the CRF tables. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet provided detailed information on this issue (such as that provided to the ERT during the review) in its NIR.

[a] References in parentheses are to the paragraph(s) and the year(s) of the previous review report(s) in which the issue or problem was raised. Issues are identified in accordance with paras. 80–83 of the UNFCCC review guidelines and classified as per para. 81 of the same guidelines.

[b] The report on the review of the 2022 inventory submission of Canada was not available at the time of this review. Therefore, the recommendations reflected in this table are taken from the 2021 inventory review report. For the same reason, 2018 and 2020 are excluded from the list of review years in which issues could have been identified.

IV. Issues identified in three or more successive reviews and not addressed by the Party

8. In accordance with paragraph 83 of the UNFCCC review guidelines, the ERT noted that the issues included in table 4 have been identified in three or more successive reviews, including the review of the 2023 inventory submission of Canada, and had not been addressed by the Party by the time of publication of this review report.

Table 4
Issues identified in three or more successive reviews and not addressed by Canada

ID#	*Previous recommendation for issue*	*Number of successive reviews issue not addressed*[a]
General	No issues identified.	
Energy		
E.5	Finalize the update of the methodological documentation on the Motor Vehicle Emissions Simulator and Nonroad Engines, Equipment and Vehicles models and include a summary of the documentation in the NIR.	4 (2017–2023)
IPPU		
I.6	Include the allocation of NEU of other reductants identified in this category in the improvement plan and implement steps to further disaggregate the energy statistics and other (industrial processes) category.	7 (2014–2023)
I.13	Implement the scheduled improvements for this category, report on progress and continue the improvements necessary to document the methods and sources of AD and EFs in the NIR.	10 (2011–2023)
I.16	Investigate whether the SF_6 and PFC uses mentioned in the 2006 IPCC Guidelines (vol. 3, chap. 8.3) occur in the country. If emissions from such uses do not occur, report them as “NO”. If emissions from such uses do occur, estimate and report them or, if they are considered insignificant, report them as “NE”, provide in the NIR a justification for the insignificance, in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines, and explain in CRF table 9 why these emissions are reported as “NE”.	3 (2019–2023)
I.17	Report on PFCs used in electronic insulators and for heat transfer in the electronics industry under category 2.E.1 instead of category 2.G.4.	3 (2019–2023)
Agriculture		
A.1	(a) Provide in the NIR sufficient information and data on the categorization of animal used (subcategory list and a description of the subcategories used in the estimations), AD (number of animals per province and subcategory of animal), parameters (i.e. MCF, VS, biodegradability of manure, animal waste management systems, Nex rate, weight, daily weight gain, mature weight, mean winter temperature, milk production, milk fat content, percentage of females that give birth in a year, number of offspring, feed digestibility and any other parameter used in the estimations), equations and EFs used for the estimates of enteric fermentation and manure management of dairy cattle, non-dairy cattle and swine at the level of disaggregation used in the estimations;	3 (2019–2023)

ID#	*Previous recommendation for issue*	*Number of successive reviews issue not addressed*[a]
	(b) Explicitly explain changes along the time series (e.g. if weight changes between subcategories and provinces, report the information at the subcategory and regional level).	
A.2	Provide clear references for the sources of the data, parameters and EFs, as well as documentation on any assumption used in the calculations following the protocol for expert elicitation included in the 2006 IPCC Guidelines (vol. 1, annex 2A.1, chap. 2).	3 (2019–2023)
A.4	Where a model is used to obtain any parameter or EF used in the estimates (e.g. swine growth model), provide the following information, as suggested in the IPCC (2011) document *Use of Models and Facility-Level Data in Greenhouse Gas Inventories*, to assess the model: basis and type of model (statistical, deterministic, process-based, empirical, top-down, bottom-up, etc.); application and adaptation of the model; main equations and processes; key assumptions; domain of application; how the model parameters were estimated; description of key inputs and outputs; details of calibration and evaluation with calibration data and independent data; description of the approach to the uncertainty and sensitivity analyses, and the results of these analyses; QA/QC procedures adopted; and references to peer-reviewed literature.	3 (2019–2023)
	If the information is too extensive to be included in the NIR, even as an annex, publish all of the information requested in a publicly available methodological report and reference that document in the NIR as a source of information.	
A.6	(b) Provide quantitative and qualitative information on the values used for all parameters involved in the tier 2 estimation of enteric fermentation at the regional level, including detailed references to the sources of the information and assumptions used;	3 (2019–2023)
	(c) Ensure consistency when determining the parameters by region and animal type by developing a transparent protocol by which to assign the values and revise the estimates, when appropriate.	
A.8	Provide in the NIR the reasons why emissions from anaerobic lagoon and daily spread have not been estimated, in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines.	5 (2016–2023)
A.9	Construct a time series of average temperatures for each region for 1990–2017 and use MCFs for all animals on the basis of those average annual temperatures and in line with the 2006 IPCC Guidelines (i.e. using the 10 °C value if the average annual temperature is below 10 °C).	3 (2019–2023)
A.11	(a) Provide in the NIR a detailed description of the methodologies used in estimating the VS of swine, as well as the values of the parameters by subcategory and region (i.e. weight, weight gain, VS and any other parameter used) and explicit references to the sources of data (i.e. document, page, table, row and column).	3 (2019–2023)
A.13	Estimate indirect N_2O emissions from MMS due to leaching and run-off by using a tier 2 approach and by developing the value of $Frac_{leachMS}$ on the basis of country-specific data on N run-off and leaching from MMS.	4 (2017–2023)
A.15	Report direct N_2O emissions from sewage sludge and other organic fertilizers applied to soils.	6 (2015–2023)
A.16	When estimating direct N_2O emissions from application of sewage sludge and other organic fertilizers to soils, also estimate the related indirect N_2O emissions.	5 (2016–2023)

ID#	*Previous recommendation for issue*	*Number of successive reviews issue not addressed*[a]
A.17	(a) Develop the underlying AD time series for limestone and dolomite, for example by using the ratio of limestone to dolomite used to calculate the weighted EF, and use the corresponding IPCC default EFs separately for limestone and dolomite, as specified in the 2006 IPCC Guidelines (vol. 4, chap. 11.3.2).	3 (2019–2023)
LULUCF		
L.1	Improve the completeness of reporting of the pools in all mandatory categories currently reported as "NE" and include a description of how the notation keys have been used.	8 (2013–2023)
L.2	Improve the completeness of land area representation for the LULUCF sector by amending the reporting (both the land-use change matrix and the estimates for category-specific emissions and removals in the CRF tables) by including all land areas and making it clear which categories and subcategories occur in Canada and whether the emissions/removals are calculated. This includes both managed land areas for which no emissions or removals are expected (e.g. grassland remaining grassland) and unmanaged areas.	6 (2015–2023)
L.5	(a) Ensure that, for all years and all land-use categories in the land-use matrix, the values reported for year X–1 in the "final area" row in CRF table 4.1 equal the values reported in year X in the "initial area" column to improve the consistency of the land use and land-use change reported and ensure consistency with the area changes reported in the sectoral background tables; (b) Recalculate the associated emissions and removals, where appropriate; (c) Explain in the NIR the reason for recalculating the associated GHG emissions and removals as a result of the land-transition matrices being revised.	3 (2019–2023)
L.7	(b) Include in the NIR a land-use matrix that shows the annual changes in areas of forest land that qualify as being subject to natural disturbances, together with a table containing their emissions and removals.	3 (2019–2023)
L.9	(a) Include the loss of the biomass in cropland in the CSC in living biomass due to conversion of cropland to forest land for all types of cropland, including abandoned cropland; (b) If the biomass losses are already accounted for under cropland in the Century model, transparently document in the NIR how they are already accounted for.	4 (2017–2023)
L.11	(a) Estimate all the direct N_2O emissions as well as the associated indirect N_2O emissions from N mineralization or immobilization associated with loss or gain of soil organic matter; (b) Until the estimation is implemented, provide information on the planned improvement and assessment of the quantitative impact of this missing category in accordance with the provisions in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines.	6 (2015–2023)
L.13	Include in the NIR a clear explanation of the assumptions and methods applied for estimating emissions from HWP for 1900–1940.	3 (2019–2023)
Waste		
W.4	Include the total organic product in CRF table 5.D for both municipal and industrial wastewater.	3 (2019–2023)

ID#	*Previous recommendation for issue*	*Number of successive reviews issue not addressed*[a]
W.7	(b) Ensure that all biogas reported for energy recovery in the waste sector is included under the energy sector.	3 (2019–2023)

[a] Reports on the reviews of the 2018, 2020 and 2022 inventory submissions of Canada have not yet been published. Therefore, 2018, 2020 and 2022 were not included when counting the number of successive years for this table.

V. Additional findings made during the individual review of the Party's 2023 inventory submission

9. Table 5 presents findings made by the ERT during the individual review of the 2023 inventory submission of Canada that are additional to those identified in table 3.

Table 5
Additional findings made during the individual review of the 2023 inventory submission of Canada

ID#	*Finding classification*	*Description of finding with recommendation or encouragement*	*Is finding an issue?*[a]
General			
G.3	CRF tables	The Party left empty cells in CRF table 6 for indirect CO_2 emissions for the energy, IPPU, agriculture and waste sectors. During the review, the Party indicated it had difficulties in reporting notation keys in CRF table 6 when using CRF Reporter. The Party explained that its preferred option is to report "NA" for indirect CO_2 emissions for all sectors apart from LULUCF. However, when "NA" is reported, the status report (part 3, "Provision of selected information in the CRF tables") states that values are provided, which is not the case. Given that reporting indirect CO_2 emissions is not mandatory, and that CRF Reporter's completeness test (traffic light system) does not flag empty cells for indirect CO_2 emissions, Canada decided that the most appropriate option was to leave the cells empty. The ERT recommends that the Party estimate and report indirect CO_2 emissions for the energy, IPPU, agriculture and waste sectors in CRF table 6 or report the appropriate notation keys and explain their use in the NIR and CRF table 9.	Yes. Comparability
G.4	Key category analysis	The Party reported in NIR table A1-2 (part 2, annex 1) the results of a key category analysis following approach 1 of the 2006 IPCC Guidelines (vol. 1, chap. 3.2). During the review, the ERT noted that approach 2 of the 2006 IPCC Guidelines can be used to identify key categories when an uncertainty analysis has been carried out. The Party indicated that it will consider this suggestion in a future submission, when time and resources allow. The ERT encourages Canada to implement approach 2 for the key category analysis of the inventory in addition to approach 1, noting that it will be helpful in prioritizing activities to improve inventory quality and to reduce overall uncertainty.	Not an issue

ID#	*Finding classification*	*Description of finding with recommendation or encouragement*	*Is finding an issue?*[a]
Energy			
E.13	1.A Fuel combustion – sectoral approach – other fossil fuels – CO_2, CH_4 and N_2O	The Party reported consumption of other fossil fuels for categories 1.A.2.f non-metallic minerals and 1.A.4.a commercial/institutional in CRF tables 1.A(a)s2 and 1.A(a)s4. However, the Party did not specify what the other fossil fuels were in order to clarify how emission estimates were determined. During the review, the Party clarified that the consumption of other fossil fuels corresponds to the energy use derived from the burning of waste in cement factories and in the commercial/institutional sector. The ERT recommends that the Party clearly specify in the NIR and in the documentation box in the CRF tables what type of other fossil fuels, including what type of waste, is combusted for energy use and reported as other fossil fuels for categories 1.A.2.f (non-metallic minerals) and 1.A.4.a (commercial/institutional) in CRF tables 1.A(a)s2 and 1.A(a)s4.	Yes. Transparency
E.14	1.A Fuel combustion – sectoral approach – liquid, solid and gaseous fuels – CO_2	The Party reported in its NIR (part 2, annex 6, section 6.1, including tables A6.1-1, A6.1-5 and A6.1-9) CO_2 EFs in units of mass of CO_2 per physical unit (volume or mass) of fuel; these EFs were used for the sectoral approach. In annex 3 to the NIR, the Party reported the methodology used to obtain the EFs and AD, indicating sectoral approach emissions were based on AD in physical units and EFs in units of mass of CO_2 per physical unit (volume or mass) of fuel. In NIR table A4.2 (part 2, annex 4) the Party reported aggregated carbon EFs in mass of carbon (t C) per energy unit (TJ); these EFs were used for the reference approach. The ERT noted that reporting sectoral approach EFs in physical units makes it difficult to compare them against IPCC default EFs and that some CO_2 EFs listed in NIR table A4.2 are outside the range of default EF values in the 2006 IPCC Guidelines (vol. 2, chap. 1, table 1.3). For example, for other bituminous coal, the EF reported in NIR table A4.2 is 22.9 (t C/TJ converted to net calorific value) whereas the default EF range from the 2006 IPCC Guidelines (vol. 2, chap. 1, table 1.3) is 24.4–27.2 (t C/TJ). During the review, the Party clarified that all AD are reported in natural units (e.g. volume or mass, but not energy units) and that its sectoral approach calculation methodology is based on EFs in natural units, specific to each region and each year, which are estimated using sampling and direct measurement. The ERT recommends that the Party provide in its NIR detailed information on how the country-specific EFs reported in annexes 4 and 6 to the NIR were developed, including the information that all AD are reported in natural units (e.g. volume or mass, but not energy units), that the sectoral approach calculation methodology is based on EFs in natural units, for each region and each year, and that, as country-specific EFs are based on direct measurement and sampling, they are more accurate and representative of Canadian fuel composition than the default values in the 2006 IPCC Guidelines (vol. 2, chap. 1, table 1.3).	Yes. Transparency
E.15	1.A Fuel combustion – sectoral approach – all fuels	In NIR table A3.1-1 (part 2, annex 3, p.21), the Party provided references to the sources of AD for fuel combustion, including links to data from the *Report on Energy Supply and Demand in Canada*. In addition NIR tables A3.1-2–A3.1-5 (part 2, annex 3) detail the specific tables in the *Report on Energy Supply and Demand in Canada* from which the data are taken for each inventory category. The ERT noted that the links provided in NIR table A3.1-1 do not correspond exactly to the references in NIR tables A3.1-2–A3.1-5, making it difficult to understand which AD are being used in the fuel combustion estimates. For example, the link in table A3.1-1 to table 25-10-0030-01 (“Supply and demand of primary and secondary energy in natural units”) seems to imply that the latter includes AD	Yes. Transparency

ID#	Finding classification	Description of finding with recommendation or encouragement	Is finding an issue?[a]
		for different types of primary and secondary fuels, but the latter only includes AD for coal. In addition, the reference to AD for refined petroleum products is not included in table A.3.1-1. During the review, the Party clarified that Statistics Canada, the organization that compiles the *Report on Energy Supply and Demand in Canada*, has updated its website, on which the data are available, and the way in which the data are accessed. The Party indicated that it plans to update annex 3 to the NIR to reflect the new format of and links to the data from the *Report on Energy Supply and Demand in Canada*. The ERT recommends that the Party, in annex 3 to the NIR, update the links to the sources of AD in the *Report on Energy Supply and Demand in Canada* and amend the text in the NIR so that it is clear which AD are used to estimate emissions from fossil fuel combustion.	
E.16	1.B.1.a Coal mining and handling – CO_2	For some years (2016, 2020 and 2021) the Party reported that there were no underground coal mining activities. For these years, the Party reported AD and fugitive CH_4 emissions as "NO" and the CO_2 emissions associated with this activity as "NA" in CRF table 1.B.1. For the years in which the activity occurred, the Party reported fugitive CH_4 emissions but reported the CO_2 emissions as "NA". There is no explanation for the use of this notation key in the NIR. During the review, the Party clarified that it considers the years in which the underground mines were closed to be years with no activity. It explained that when there is activity, there are no CO_2 emissions associated with flaring and drainage, and noted that this assumption is based on studies that demonstrate that there are no CO_2 emissions (e.g. King, 1994; Cheminfo Services and Clearstone Engineering, 2014). The ERT recommends that the Party (1) report, in CRF table 1.B.1, CO_2 emissions for the years when underground coal mines are not in operation (2016, 2020 and 2021) as "NO" instead of "NA" and (2) improve the justification in its NIR for the assumption that no fugitive CO_2 emissions occur during underground coal mining.	Yes. Comparability
E.17	1.B.1.b Solid fuel transformation – CO_2 and CH_4	The Party reported CO_2 and CH_4 emissions from solid fuel transformation as "NE" in CRF table 1.B.1. The NIR (part 1, section 3.3.1.1) indicates that the maximum likely level of emissions is 260 kt CO_2 eq, which is below the significance threshold established in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines (0.05 per cent of national total emissions excluding LULUCF for the latest reported year (i.e. 335.31 kt CO_2 eq for Canada's 2023 submission) and not exceeding 500 kt CO_2 eq). However, Canada reported AD as "NA" in CRF table 1.B.1. During the review, the Party indicated that the activity occurs, but the emissions have not been estimated. The ERT noted that the AD should be reported as "NE" when the activity occurs but the emissions are not estimated. The ERT recommends that the Party change the notation key for reporting AD under category 1.B.1.b solid fuel transformation from "NA" to "NE".	Yes. Comparability
E.18	1.B.2.b Natural gas – post-meter fugitive emissions – CO_2	The Party reported CO_2 emissions associated with post-meter fugitive emissions under subcategory 1.B.2.b.6 other in CRF table 1.B.2, explaining in the NIR (part 1, p.88) that they are fugitive emissions occurring at the final point of consumption. However, the ERT noted that all natural gas used in the residential sector is captured under the national energy balance used to calculate fossil fuel combustion CO_2 emissions, and part of that gas combustion is presumably the cause of post-meter fugitive emissions. If 100 per cent combustion is assumed for a fuel, post-meter fugitive CO_2 emissions would be included in the fossil fuel combustion estimates and those emissions would be double counted.	Yes. Accuracy

ID#	*Finding classification*	*Description of finding with recommendation or encouragement*	*Is finding an issue?*[a]
		During the review, the Party clarified that post-meter fugitive CO_2 emissions were estimated using the tier 1 default CO_2 EFs in the 2019 Refinement to the 2006 IPCC Guidelines (vol. 2, table 4.2.4K) adapted to the CO_2 content of marketable natural gas in Canada (which is generally less than 1 per cent by volume). The Party also clarified that Canada's CO_2 EFs for natural gas combustion assume 100 per cent oxidation of all carbon in a fuel, as recommended in the 2006 IPCC Guidelines (vol. 2, chap. 1, table 1.4), and therefore they include any CO_2 in the marketable gas. The Party acknowledged that in this context, post-meter fugitive CO_2 emissions are also included in the fossil fuel combustion CO_2 estimates.	
		The ERT recommends that the Party exclude CO_2 emissions from estimates of post-meter fugitive emissions in cases where the emissions are already captured as part of natural gas fuel combustion AD and where the assumption of 100 per cent oxidation for fuel combustion is made, and explain any recalculation of AD, EFs and emission estimates in the NIR.	
IPPU			
I.18	2.A.1 Cement production – CO_2	Canada reported in CRF table 2(I).A-Hs1 the IEF for cement production. The ERT noted that there is a dip in 2018, where the IEF is 0.512 t/t compared with 0.546 t/t in 2017 and 0.538 t/t in 2019, which is not explained in the NIR.	Yes. Convention reporting adherence
		During the review, Canada clarified that plant-specific data were used for preparing the estimates for 2017 onward and that the observed dip in 2018 is a consequence of the AD reported by one of the facilities. In addition, Canada explained that a transcription error in clinker production data was identified for 2018 that, when corrected, will increase the IEF for 2018 to 0.516 t/t but that follow-up with the facility will be needed to explain the still rather low IEF. The ERT noted that it is highly unusual to see such large inter-annual variations at the plant level without, for example, a major change in the sourcing of raw materials.	
		The ERT recommends that Canada correct the transcription error in clinker production data for 2018, work with the facilities providing data to check the accuracy of the reporting across the time series and explain any recalculations in the NIR.	
I.19	2.A.2 Lime production – CO_2	Canada reported in CRF table 2(I).A-Hs1 the CO_2 IEFs for lime production. The IEFs (t/t) are notably higher in 2019 (0.808) and 2021 (0.813) compared with the rest of the time series (0.76–0.78), but there is no explanation for this in the NIR.	Yes. Consistency
		During the review, Canada explained that the IEF is developed using national lime production data from Statistics Canada, but CO_2 process emissions are those reported by lime production facilities under Canada's Greenhouse Gas Reporting Program. Furthermore, Canada indicated that it will initiate a discussion with Statistics Canada on the national lime production data and investigate possible solutions to resolve the discrepancy.	
		The ERT recommends that Canada investigate the unusually high CO_2 IEFs for lime production in 2019 and 2021 (0.808 and 0.813 t/t respectively) and ensure that the AD reported in the CRF are consistent with the CO_2 emission estimates reported.	
I.20	2.A.4 Other process uses of carbonates – CO_2	The ERT noted that there is a significant decrease in the AD for other uses of limestone and dolomite reported under category 2.A.4.d other between 2009 (1,033 kt) and 2010 (529 kt) but no explanation for this trend in the NIR.	Yes. Transparency

ID#	*Finding classification*	*Description of finding with recommendation or encouragement*	*Is finding an issue?*[a]
		During the review, Canada explained that this decrease is due to some companies reporting low or no quantities of carbonates sold or used for some chemical process applications. However, it was not clear whether the decrease was caused by companies ceasing operations or changing their processes in a way that stopped or decreased the use of carbonates. Canada indicated that it will contact Natural Resources Canada to investigate the large decrease over these years. The ERT recommends that Canada investigate the reasons for the large decrease in the consumption of carbonates between 2009 and 2010 and include the explanation in the NIR, and, if applicable, explain any recalculation of the emission estimates.	
I.21	2.C.2 Ferroalloys production – CO_2 and CH_4	Canada reported AD and CO_2 and CH_4 emissions as "IE" in CRF table 2(I).A-Hs2. In CRF table 9, it indicated that those emissions are reported under categories 2.C.1.a steel and 2.C.1.b pig iron. However, there is no section on ferroalloys production in the body of the NIR; ferroalloys production is mentioned in annex 3.3 to the NIR under iron and steel production. During the review, the Party explained that there were four plants producing ferroalloys in 2021 in Canada and only two applied processes that lead to CO_2 emissions, hence, emissions cannot be reported owing to confidentiality reasons. Furthermore, Canada clarified that CO_2 emissions are included under category 2.C.1.a and CH_4 emissions are included under 2.C.1.b and that the explanation for reporting these emission as "IE" will be updated in the next submission. The ERT recommends that Canada (1) include a separate section in the body of the NIR providing information on the ferroalloys industry in Canada (number of plants, applied processes, methodology used to estimate emissions) and on the allocation of CO_2 and CH_4 emissions from this industry to the inventory and (2) update the explanation for any reporting of "IE" in CRF table 9.	Yes. Transparency
I.22	2.F Product uses as substitutes for ODS – HFCs	The NIR (part 2, annex 3.3.4, pp.81–82) includes a description of the sources of AD for fluorinated gas use. From this description, it is clear that bulk importers and exporters are surveyed regularly, but that no recent survey has been conducted for HFCs imported in products (the last survey was in 2010). During the review, Canada clarified that AD for HFCs imported in products have been extrapolated since 2010. The Party also explained that it has been exploring ways to update the information (e.g. by cooperating with the United States Environmental Protection Agency), but it is unclear whether these efforts will be successful and, even if they are, the improvement will not be implemented in the inventory until the 2025 or 2026 submission. The ERT considers that extrapolating from 2010 (i.e. a long period) can result in significant overestimates or underestimates of the emissions. The ERT recommends that Canada collect data on HFCs imported in products either by cooperating with exporting countries or by surveying importers and, if applicable, explain any recalculation of the emission estimates. The ERT also recommends that Canada, while the work on collecting data is ongoing, include information in the NIR on how the current extrapolation is performed and on how the plans to collect updated data are progressing.	Yes. Accuracy
I.23	2.F Product uses as substitutes for ODS – HFCs	Canada reported information on all the HFC EFs used (NIR part 2, annex 3, section 3.3.4.3). Canada mostly makes use of EFs from a study carried out in 2013 for refrigeration and air conditioning and default values from the 2006 IPCC Guidelines for foam blowing. The country-specific EFs have been kept constant throughout the time series.	Yes. Accuracy

ID#	*Finding classification*	*Description of finding with recommendation or encouragement*	*Is finding an issue?*[a]
		The ERT noted that industry practices change and it is likely that changes to the EFs will have occurred during the time series – this could be especially relevant for the disposal loss factor (or fraction recovered). During the review, Canada agreed that it would be appropriate to look into the EFs for disposal loss and indicated its intention to investigate them. The ERT recommends that Canada carry out an investigation with the goal of updating or verifying the current EFs for refrigeration, air conditioning and foam blowing used in the Canadian inventory across the time series, with a focus on end-of-life EFs, report on progress in the NIR and, if applicable, explain any recalculation of the emission estimates.	
Agriculture			
A.18	3.A.1 Cattle and 3.B.1 Cattle – CH_4	The Party reported in its NIR (part 1, section 5.2, p.151) and CRF tables 3.As1 and 3.As2 enteric fermentation emissions, and in CRF table 3.B(a)s2 the assumption on MMS allocation for dairy and non-dairy cattle. For the estimation, Canada uses the tier 2 approach. Assumptions on AD for the estimation of enteric fermentation emissions from cattle (dairy cattle and non-dairy cattle) are based on a study from 2004 and assumptions on MMS allocation are based mostly on a study from 2005. Although according to Canada (NIR part 1, section 5.2, p.151), over 1990–2021 animal agriculture in the country has undergone a process of intensification by increasing farm and herd sizes and increasing protein concentrations in diets, the references on which the assumptions on AD for dairy and non-dairy cattle and MMS allocation are based are 20 years old and probably do not reflect the changes experienced by livestock production systems in that period in the country (see ID# A.9 in table 3). The ERT noted that this is not in accordance with the 2006 IPCC Guidelines (vol. 4, chap. 10.2.2) because it may not adequately reflect the current situation of key herd and farm parameters for dairy cattle and non-dairy cattle production systems in Canada. As a result, the estimates reported may not be accurate. During the review, the Party indicated that the parameters for Canada's tier 2 methodology originating from Boadi et al. (2004) are based on expert opinion surveys, and further validation has not been carried out. In addition, it provided a list of planned improvements being considered for the agriculture sector, such as actions associated with AD improvement for cattle production systems in the medium term. The ERT recommends that the Party validate animal population and herd characteristics for non-dairy cattle and MMS allocation for dairy cattle for recent years, use the validated information to estimate enteric fermentation emissions for dairy cattle and non-dairy cattle and emissions from MMS for dairy cattle and non-dairy cattle for recent years, and explain in the NIR the recalculations and the approach followed for the validation of parameters.	Yes. Accuracy
A.19	3.A.1 Cattle – CH_4	The Party reported enteric fermentation emissions from dairy cattle using the tier 2 methodology in its NIR (part 1, section 5.2, p.151) and CRF table 3.As1, explaining that there are no statistics available on total national milk production. Canada also explained that the value of national milk production used for the estimation of the country-specific EF (kg CH_4/head/year) is received from Lactanet, but this only covered two thirds of dairy farms in Canada for 2000–2019 (NIR part 2, annex 3, section A3.4.1, p.97). The ERT noted that this is not in accordance with the 2006 IPCC Guidelines (vol. 4, chap. 10, equation 10.8, p.10.18) because it may not adequately include all types of dairy farm in the estimation of individual animal production (kg/day/animal) used to calculate the enteric fermentation EF for dairy cattle, resulting in a skewed	Yes. Accuracy

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		dairy cattle individual animal production estimate, which, in turn, will affect the estimate of the country-specific EF. During the review, the Party clarified that according to its estimations the information provided by Lactanet covers 62 per cent of total milk production in the country, and that the overall bias in the calculation is considered to be small given that the milk production accounted for covers more than 50 per cent of the national herd and the number of dairy cows has a high level of certainty because it is based on Census of Agriculture estimates. The Party also provided the calculations for the estimation of milk production/cow/day per region for the time series. The ERT considers that Canada should ensure that all dairy production in the country is adequately represented in the national estimates. The ERT recommends that the Party review the assumptions made when estimating the milk production/cow/year for estimating the CH_4 EF for enteric fermentation for dairy cattle (category 3.A.1) for the entire time series, and include in the NIR a detailed description of the reviewed assumptions as well as an explanation of the recalculations, if any.	
A.20	3.B.4 Other livestock – N_2O	The Party reported in NIR table A3.4-25 (part 2, p.126) that the average body weight for buffalo (called bison in Canada) was 580 kg/animal and that this weight was used to estimate the Nex rate (kg N/head/year) for buffalo. Nevertheless, in CRF table 3.B(b), the animal weight for buffalo is reported as 578.5 kg N/head/year. The ERT noted that using the different buffalo average body weights would result in different estimations of total N excreted (by 26,199.23 kg N). During the review, the Party clarified that for the calculations in CRF table 3.B(b) it used the unrounded animal weight (578.5 kg/animal), while in NIR table A3.4-25 it reported a rounded figure (580 kg/animal). The ERT verified the estimations and agreed with the Party that the differences found for Nex and total N excreted from buffalo were due the differences in the animal weight values reported in NIR table A3.4-25 and CRF table 3.B(b). The ERT recommends that the Party correct the animal body weight for buffalo in NIR table A3.4-25 so that it is the same value as that used in the emission estimates and reported in CRF table 3.B(b).	Yes. Convention reporting adherence
A.21	3.B.4 Other livestock – CH_4 and N_2O	The Party reported in CRF table 3.B(a)s2 the MMS per animal category used for the estimation of emissions from manure management. For the animal categories buffalo, horses and poultry, the Party used “IE” to report MMS and, subsequently, emissions for biodigesters and composting allocated under the MMS “other”. The ERT noted that this is not in accordance with the 2006 IPCC Guidelines (vol. 1, chap. 1.4, p.1.7) because it reduces the transparency of the emissions reported and prevents an understanding of the trend in emissions from biodigesters and composting, which is relevant in the context of animal production system intensification in Canada over the time series (see ID# A.18 above). During the review, the Party clarified that the AD for buffalo (called bison in Canada), horses and poultry are based on expert opinion surveys documented in Marinier, Clark and Wagner-Riddle (2005). In the report, manure systems are summarized in four categories: liquid, solid, pasture range and paddock, and other. The other MMS contains both composting and anaerobic digestion. The ERT recommends that the Party estimate and report emissions separately for biodigesters and composting in the respective MMS category for buffalo, horses and poultry, and explain this recalculation in the NIR.	Yes. Comparability

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A.22	3.G Liming – CO_2	The Party reported in CRF table 3.G-I emissions from the application of lime and dolomite in agricultural soils using the tier 1 approach. For 1990–2006, the quantity of lime and dolomite used for agricultural purposes (t/year) is provided by Natural Resources Canada in the *Canadian Minerals Yearbook*. For more recent years, the information is provided by Natural Resources Canada to the inventory team. The ERT noted that not considering the concentration of calcium carbonate in lime and calcium magnesium carbonate in dolomite in the calculations and using the total amount (tonnes) of lime and dolomite for the emission estimates is not in accordance with the 2006 IPCC Guidelines (vol. 4, chap. 11, equation 11.12, p.11.29) and resulted in a slight overestimation of CO_2 emissions. During the review, the Party confirmed that the total amounts of agricultural product were used for the calculations. The ERT recommends that the Party determine the concentrations of calcium carbonate for lime and calcium magnesium carbonate for dolomite and use the amounts of calcium carbonate in lime and calcium magnesium carbonate in dolomite (t/year) for the estimation, and report CO_2 emissions from lime and dolomite in category 3.G, for the entire time series, and explain any recalculation of the emission estimates in the NIR.	Yes. Accuracy
LULUCF			
L.15	4. General (LULUCF) – CO_2	The Party did not report losses of biomass carbon stocks harvested for the production of HWP in CRF tables 4.A (for forest land), 4.B (for cropland), 4.D (for wetlands) and 4.E (for settlements). The ERT noted that this is not in accordance with the 2006 IPCC Guidelines (vol. 4, chaps. 2 and 4, equations 2.4 and 2.5) because IPCC good practice requires Parties to estimate annual CO_2 net emissions/removals from the biomass carbon pool of any land-use category as the annual net change in the resident carbon stock of the biomass carbon pool. Given that the harvest of wood, and its subsequent use, determines a transfer of carbon stocks out of the biomass carbon pool, all wood harvested is to be included in the calculation of the annual net change in the resident carbon stock of the biomass carbon pool. Furthermore, the exclusion of HWP carbon stocks from the calculation of the annual net change in the resident carbon stock of the biomass carbon pool results in a systematic underestimation of the annual net CO_2 emissions in the land category. During the review, the Party stated that this issue does not constitute bias in the estimation of CSC and GHG emissions and removals in the inventory for the LULUCF sector. The Party also stated that this apparent issue has been largely explored and understood by several ERTs in previous reviews and Canada has clearly demonstrated that there is no underestimation or overestimation of emissions/removals in the forest land and HWP categories. The Party further stated that these two categories are usually treated together under the forest or forestry sector, as noted in the NIR (part 1, chap. 2). The Party stated that the issue previously raised in relation to the reporting of HWP was considered resolved by the ERT reviewing the 2021 submission after confirming that Canada's reporting on the HWP pool is transparent and comparable with that of other Parties. The Party referred to ID# L.20 in document FCCC/ARR/2021/CAN. The ERT acknowledges that this issue is connected to the subsequent issue described in ID# L.27 below and that no errors occurred at the level of the net balance of the LULUCF sector because the two omissions (biomass losses and HWP gains) have the same magnitude but different signs, so that the total net CO_2 flux of the LULUCF sector would not be affected. However, the ERT concludes that such a deviation from IPCC good practice produces incomplete estimates of the biomass carbon pool of categories 4.A forest land, 4.B cropland, 4.D wetlands and 4.E	Yes. Completeness

ID#	Finding classification	Description of finding with recommendation or encouragement	Is finding an issue?[a]
		settlements and makes those estimates not comparable with the estimates provided by other reporting Parties that apply IPCC good practice. The ERT also concludes that the current approach is a substantial deviation from the good practice provided in the 2006 IPCC Guidelines, which underpin the UNFCCC Annex I inventory reporting guidelines, which prescribe the estimation and reporting of changes in the resident carbon stocks of the biomass carbon pools of the land-use categories 4.A–4.F. The ERT further concludes that given the magnitude of carbon transfers associated with timber harvest (40,000 kt C in 2021; NIR table 6-7), the omission of the respective forest land biomass losses and HWP gains at the category level, particularly for category 4.A forest land (36 000 kt C in 2021; NIR table 6-7), constitutes a completeness issue that de facto also constitutes a comparability issue at the forest land and HWP category level. The ERT recommends that the Party align its estimates of biomass CSCs in categories 4.A forest land, 4.B cropland, 4.D wetlands and 4.E settlements with the good practice included in the 2006 IPCC Guidelines (vol. 4, chaps. 2 and 4, equations 2.4 and 2.5) by reporting under these categories all losses of biomass carbon stocks that are harvested.	
L.16	Land representation	The Party reported the area of total unmanaged land, excluding unmanaged forest land, as 574,429.88 kha and 579,625.47 kha for 1990 and 2021 respectively in CRF table 4.1, which means that the total area of unmanaged land has increased across the time series. However, neither areas of managed land converted to unmanaged land nor information on the dynamic of the carbon stocks on managed land converted to unmanaged land are reported. The ERT noted that this is not in accordance with the 2006 IPCC Guidelines (vol. 4, chap. 3, p.3.9), which do not consider the reporting of conversion of managed land to unmanaged land as good practice. The ERT also noted that the definition of managed land in the guidelines, namely, land where human interventions and practices have been applied to perform production, ecological or social functions (vol. 4, chap. 1, p.5), does not, by definition, allow for managed land to become unmanaged land. Managed land generally cannot become unmanaged as the legacy effects of past management can continue for extended periods, and such conversions could result in anthropogenic emissions and removals being unreported. During the review, the Party clarified that the area for total unmanaged land reported in CRF table 4.1 includes both unmanaged and managed non-forest land for which the Party has not estimated CSCs. These areas are reported in CRF table 4.1 to fulfil the requirement of the UNFCCC Annex I inventory reporting guidelines to report the total land mass area of the country. The Party explained that the principal cause of the apparent increase in unmanaged land is the declining areas of cropland in the Census of Agriculture (i.e. areas that are no longer included in the agricultural land statistics but have yet to be assigned to another land-use category). The ERT recommends that the Party report (1) in CRF table 4.1 all managed land in the relevant category and not under total unmanaged land, even in cases where no net CSC is occurring in some of those managed areas; (2) in CRF table 4.1 only unmanaged land under the categories for unmanaged land; and (3) in CRF tables 4A–4.F all areas of managed land for which the Party informed the ERT that no CSCs occur (e.g. the lands no longer included in the Census of Agriculture but not yet undergoing land-use change), with associated CSCs and corresponding CO_2 emissions/removals reported as "NO", and report in the NIR a confirmation that no net CSCs are occurring on these lands.	Yes. Comparability
L.17	Land representation	The Party reported in NIR table 6-4 the categories wetlands converted to cropland, settlements converted to cropland, cropland converted to wetlands, grassland converted to wetlands, settlements converted to wetlands and	Yes. Comparability

ID#	*Finding classification*	*Description of finding with recommendation or encouragement*	*Is finding an issue?*[a]
		wetlands converted to settlements as "NE", while in the corresponding CRF table 4.1 those categories are reported as "IE". The ERT noted that this is not in accordance with the 2006 IPCC Guidelines (vol. 4, chap. 2, pp.12–13) given that approach 2 for land representation, as applied by Canada, requires Parties to estimate and report areas in conversion disaggregated, at least by the previous and current land-use category (e.g. wetlands converted to cropland). During the review, the Party clarified that the correct data set is in NIR table 6-4 and that the "IE" reported in CRF table 4.1 for these land-use change categories is to indicate that these areas are not yet estimated and are currently included in the total remaining area reported under total unmanaged land in cell K16 of CRF table 4.1. The ERT noted that the inclusion of managed land under the reporting category total unmanaged land is not consistent with IPCC good practice (see ID# L.16 above). The ERT recommends that the Party change the notation key from "IE" to "NE" in CRF table 4.1 for wetlands converted to cropland, settlements converted to cropland, cropland converted to wetlands, grassland converted to wetlands, settlements converted to wetlands and wetlands converted to settlements in order to make the reporting consistent with NIR table 6-4, given that, as noted by the Party, those land-use conversions are not estimated. The ERT also recommends that the Party ensure that the total area of each land category includes all areas of conversions classified under that category, which means that where there is not enough information to report in a land-use category one or more areas under conversion to that land-use area separately, such conversions areas are instead reported under the land use remaining land use category resulting from the conversion (e.g. the area of wetlands converted to cropland would be reported under the category cropland remaining cropland), as is the case for approach 1 for land representation. Alternatively, the ERT encourages the Party to consider estimating the land conversions that are not estimated from the known land use areas, known land conversions and known total territory, and to consider, for example, the use of secondary data sets to fill gaps.	
L.18	4.A Forest land – CO_2	The Party reported in its NIR (part 1, p.181) that the anthropogenic component of GHG estimates in forest land encompasses emissions and removals from "(i) stands that have been directly affected by past forest management activities (e.g. clear-cutting and partial harvesting, commercial and pre-commercial thinning, and salvage logging); (ii) mature stands affected by natural disturbances causing biomass mortality of 20 per cent or less (i.e. insect defoliation) or having greater than 20 per cent mortality and that have recovered to their pre-disturbance biomass; and (iii) mature stands affected by stand-replacing natural disturbances in the past that have reached a regionally-determined minimum operable age (i.e. that have reached commercial maturity and are actively monitored in forest management practice to serve the public interest)". However, managed forest land also includes forest areas not suitable for harvest (e.g. protected land) that do not match any of the listed categories. The ERT noted that this is not in accordance with the 2006 IPCC Guidelines (vol. 4, chaps. 1, 2 and 4) because all CSCs in managed land are to be reported, even from areas not suitable for harvesting. During the review, the Party clarified that, as reported in the NIR (part 1, section 6.2, p.176), in the GHG inventory managed forests are those managed for timber and non-timber resources (including parks) or subject to fire protection. The Party informed the ERT that the proportion of the area of managed forests compared with unmanaged forests varies among the 10 provinces and 3 territories in Canada. Some provinces, including British Columbia, Alberta, New Brunswick, Nova Scotia and Prince Edward Island, consider all forest land as managed	Yes. Transparency

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		owing to ongoing timber harvest, fire protection and conservation activities. In contrast, Saskatchewan, Manitoba, Ontario and Quebec delineate a northern border of managed forests based on the northern boundary of fire suppression. In these provinces, forest land areas to the north of this boundary are considered unmanaged forest land. The province of Newfoundland and Labrador includes all forests on the island of Newfoundland as managed, but limits managed forests in Labrador to those that are subject to ongoing or planned future timber harvest. Yukon and the Northwest Territories delineate managed forest as areas designated for timber harvesting and areas under fire protection surrounding communities. Nunavut does not contain any managed forests. The initial delineation of managed forests was based on geographic information system boundaries of forest management units used for timber supply planning, parks and fire protection zones. Noting the inconsistency between the criteria for managed forest land reported on pages 176 and 181 of the NIR (part 1), the ERT highlights the need for the Party to include and elaborate on in the NIR the definition of managed forest land provided to the ERT during the review. The ERT recommends that the Party ensure consistency in the use of the definition of managed forest land within the NIR by (1) identifying the areas of forests that do not match any of the three types of forest land described in the 2023 NIR (part 1, p.181) but are nonetheless considered, as per the national definition, as managed forest land (e.g. protected land); and (2) providing information on whether the GHG emissions and removals on such land are estimated and on the method applied to estimate CSCs on the land.	
L.19	4.A Forest land – CO_2	The Party reported conversion of unmanaged forest land to managed forest land as "IE" in CRF table 4.1 given that managed forest areas can occasionally increase over time if management activities expand into areas currently considered unmanaged forests. Managed forest land can only leave this category through land-use conversion. Once forests are considered managed they remain in that reporting category. Unmanaged forests can become managed forests if, for example, forest road construction and timber extraction commence, or if they meet other managed forest criteria. Unmanaged forests are monitored through Canada's comprehensive deforestation monitoring programme to ensure that resource extraction (e.g. mining), road construction, agricultural and urban expansion, and reservoir flooding events, which cause conversion of forest to non-forest land uses, are identified and the resulting emissions are reported in the national GHG inventory. The ERT noted that not estimating CSCs associated with changes in forest management, for example the conversion of unmanaged forest land to managed forest land, is not in accordance with the good practice included in the 2006 IPCC Guidelines (vol. 4, chap. 4, pp.7 and 29), which require the estimation of CSCs associated with changes in forest management. During the review, the Party clarified that the conversion of unmanaged forests to managed forests currently only occurs as a result of deforestation in unmanaged forests. Expansion of industrial forest management activities into unmanaged forests is tracked by the province or territory in which the expansion occurs, and this has not been integrated into the inventory data, resulting in a potential underestimate of the managed forest area. Once the provinces and territories have established forest inventories for these areas, they will be incorporated into the national inventory estimates by inputting the new data into NFCMARS, which is used by the Party to estimate national emissions and removals from forest land reported in the inventory. This incorporation is a labour-intensive, multi-year process for each jurisdiction involved. Several projects in the current improvement plan are intended to address this.	Yes. Accuracy

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		The ERT recommends that the Party estimate and report areas of unmanaged forest land converted to managed forest land in CRF tables 4.1 and 4.A, and estimate and report the associated CSCs in CRF table 4.A. The ERT encourages the Party to prioritize this improvement given the importance of forest land to the overall annual net GHG emissions of the Party's inventory.	
L.20	4.A Forest land – CO_2	The Party reported in its NIR (part 1, p.184) that Shaw et al. (2014) compared the carbon stock values predicted by CBM-CFS3 with ground plot-based estimates of ecosystem carbon stocks from Canada's latest NFI available at that time. The ERT noted that the relevant variables for carbon pool related estimates are carbon stock gains and carbon stock losses, or at least the net CSCs over a certain period, and that estimates prepared for forest land by the current version of the model significantly differ from those prepared by the version of the model that was verified by Shaw et al. (2014) (the carbon stock values predicted by CBM-CFS3 as reported in the 2010 inventory submission). For example, the total net CO_2 removal for 2008 is 74,617.49 Gg in the 2010 inventory submission, while it is 141,832.12 Gg in the 2023 submission. The ERT noted that not verifying model outputs regularly is not in accordance with the 2006 IPCC Guidelines (vol. 1, chap. 6, and vol. 4, chap. 2.5.2), which state that verification of model outputs is an activity to be performed with continuity across inventory cycles to enhance the accuracy of estimates and minimize the associated uncertainty across inventory cycles, given that models are continuously modified and that natural variables, as well as management practices and the regime of disturbances, tend to vary across time, especially in the context of increasing global temperatures. During the review, the Party clarified that the noted changes in the estimates between the 2010 and 2023 submissions are mainly attributable to input data updates (e.g. forest inventories and yield curves, disturbance input data) rather than model structure or parameter changes. As a result, the evaluation of Shaw et al. (2014) would show essentially identical results if it were repeated today using the updated input data. The Party explained that some soil and DOM carbon remeasurement data for NFI plots recently became available, and these are being analysed. However, the number of available ground plot remeasurements is small, and the sampling methodology used by the NFI may not be sufficiently precise to detect the small changes expected to occur over short timescales. The Party explained that, nevertheless, model evaluation and verification is an ongoing activity and that following Shaw et al. (2014) a national-scale calibration study for soil and DOM carbon modelling parameters was undertaken (Hararuk, Shaw and Kurz, 2017) using a more comprehensive database of upland forest soil carbon observations (Shaw et al., 2018a). Updating NFCMARS to reflect these parameters is included in the inventory improvement plan. Shaw et al. (2018b) found that only 20 of 45 model parameters could be constrained by the available data, suggesting that further improvement beyond updating the parameters will require the inclusion of additional processes or a change in the modelling approach. Additional analyses have been undertaken at the site scale, comparing hybrid biometric model estimates derived using a combination of tree-ring observations and CBM-CFS3 against eddy covariance derived estimates (e.g. Metsaranta et al., 2018; Metsaranta et al., 2021), and at the provincial level by independent researchers (e.g. Hagemann et al., 2010; Heffner, Steenberg and Leblon, 2021) to compare estimates against provincial forestry plot data. In general, like Shaw et al. (2014), these studies found that there is good agreement between estimates for some carbon stock and flux indicators, but for some carbon stock and flux indicators the agreement could be improved. These results are used to inform future model improvement activities and priorities. For example, ongoing analyses aim to determine whether additional parameter stratification by soil type (e.g. Shaw et al., 2018b) or tree species will improve the model estimates. At	Yes. Transparency

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		larger scales, analyses are being conducted to compare estimates of above-ground biomass with independent estimates provided by remote-sensing data products (e.g. Tompalski et al., in preparation). Finally, a stock change analysis focusing on merchantable wood is ongoing in the province of Quebec, based on its extensive forest inventory, and will cover the entire time series. Focusing on merchantable stocks will allow a relatively direct comparison with CBM-CFS3 as it is largely driven by yield curves. Understanding the magnitude and cause of variation in tree and forest growth is one of the core problems of forest science, and the Party therefore expects that the Canadian Forest Service will continue to conduct such studies in the future. It is known that tree- and stand-level growth, mortality and recruitment of trees within modelled cohorts have been changing in response to changes in the climate and other environmental conditions. These issues have been examined by many scientists over the past decade or more, and comprehensively reviewed in Marchand et al. (2018), who found that conclusions regarding increases or decreases in forest growth rate depend on the species, region and type of data used for inference (forest plots, tree rings or remote sensing). A possible consensus suggests that climate change enhances growth rates on the cold margin of species distribution if moisture is not a limiting factor and increases mortality in dry regions, but this requires ongoing evaluation. The Canadian Forest Service, including Carbon Accounting Team scientists, is continuing to be involved in research activity that aims to determine whether, where and by how much forest growth, mortality and recruitment rates are changing, and how to incorporate this information into NFCMARS. Examples of this kind of activity include the development and analysis of a comprehensive national-scale database of tree-ring observations that builds on a core of data collected at NFI plots, which showed no overall growth increase in Canada's boreal forest. This database is being expanded to cover more recent time periods and is expected to generate an updated assessment of growth trends. The ERT, while acknowledging the significant amount of work in progress, recommends that the Party provide in the NIR (1) the latest results of its verification work for the carbon stock values predicted by CBM-CFS3 and (2) its plan for the continuous run of verification checks for the carbon stock values predicted by CBM-CFS3 in all future NFI cycles. The ERT encourages the Party to prioritize the continuous verification of the model's outputs among its planned improvements.	
L.21	4.A Forest land – CO_2	The Party reported in NIR table 6-5 net emissions from managed forest land disaggregated between "anthropogenic impact" and "natural disturbances impact" for 1990, 2005 and 2016–2021. The figures are not disaggregated into gross CO_2 emissions and gross CO_2 removals, as required to ensure the needed transparency in the disaggregation of total CO_2 net emissions in the two components. The ERT noted that the partial reporting of information on the "anthropogenic impact" and "natural disturbances impact" does not allow a complete understanding of processes and associated anthropogenic CO_2 emissions and removals that are included under the net total emissions/removals of category 4.A forest land. During the review, the Party provided the ERT with a complete time series of gross CO_2 emissions and gross CO_2 removals associated with the various drivers, including harvest, wildfires and pests, aggregated in the two components ("anthropogenic impact" and "natural disturbances impact"). The ERT recommends that the Party report in the NIR gross CO_2 emissions and gross CO_2 removals from managed forest land associated with various drivers, including harvest, wildfires and pests, which are currently reported in	Yes. Transparency

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		aggregate under "anthropogenic impact" and under "natural disturbances impact", for the entire time series or provide a link to where these data can be found.	
L.22	4.A Forest land – CO_2	The ERT noted the following two interrelated accuracy issues in the reporting of methods applied to disaggregate GHG emissions and removals of managed forest land into anthropogenic and natural disturbance components: (a) **Inconsistency with the IPCC definition of natural disturbance.** The Party cited multiple scientific studies in its NIR (part 1, p.160) to demonstrate that human actions can have both negative and positive effects on forest fires, through starting fires accidentally or intentionally (for management activities) and actively suppressing fires and controlling fuel. The effects of human actions on the occurrence of, and associated areas affected by, wildfires are thus difficult to quantify and separate from non-anthropogenic factors that concurrently influence fire disturbances. The Party concluded that the above-mentioned studies could not clearly identify a positive or negative net anthropogenic impact on fires in Canada, suggesting that although Canada invests significant resources in fire control, anthropogenic activities do not have a net impact on the area burned by wildfires. Consequently, the position of the Party is that increased sources of ignition resulting from human actions in forests and fire suppression efforts together result in a net zero impact on wildfires, particularly compared with the overwhelming impact of weather patterns and cycles on annual areas burned. This position qualifies all emissions (and all subsequent removals) from wildfires under the natural disturbance component and excludes them from the anthropogenic component. However, the Party applies a threshold of 20 per cent mortality of the standing biomass to distinguish events (and associated emissions/removals) of the natural disturbance component from the anthropogenic component. All disturbances by natural agents (fire, wind and pests) that cause a mortality higher than 20 per cent are considered to be of the natural disturbance component only, which results in all stand-replacing disturbances by natural agents being considered under the natural disturbances component only (NIR part 1, p.181). Although the ERT is cognizant that all over the world the main driver of changes in wildfire frequency and intensity is climate variability, it considers that the Party's assumption that human activity has neither a positive nor a negative net impact on the wildfire regime across the country is not supported by long-term data and scientific understanding. In addition, such an assumption (i.e. that there is no net human impact on every wildfire disturbance) is not in accordance with the managed land proxy in the 2006 IPCC Guidelines (vol. 4, chaps. 1–4) given that the IPCC qualifies GHG emissions and removals from managed lands as the dominant result of human activity, and thus the human impact on every disturbance (including wildfires) cannot be assumed neutral unless evidence is provided. The ERT also considers that human activities, including forest management, determine changes in forest ecosystems, including in the structure and the level of the biomass stock, and that in the absence of those human activities (including fire suppression activities), fire disturbance regimes would be different in terms of intensity, extent and frequency, thus affecting resident carbon stocks and land–atmosphere fluxes of CO_2. For instance, the NIR (part 2, p.160) cites Hanes et al. (2019) in stating that 10 per cent of the total forest area burned (i.e. including managed and unmanaged forest land) is started by human-caused ignitions. The NIR does not, however, provide substantiated evidence that this and other human-induced influences that trigger fire events or affect fire regimes are completely offset by anthropogenic factors in the opposing direction. As pointed out in studies by scientists from Canada and the United States of America (among others, Parisien et al. 2016), the specific mechanisms by which humans alter fire ignition and spread may be difficult, or even impossible, to	Yes. Accuracy

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		identify. Furthermore, Parisien et al. (2016) suggest that there are few purely natural fire regimes in North America today. The ERT recognizes that events and circumstances may occur that cause significant emissions (and subsequent removals) that are beyond the control of the country and are not materially influenced by it, which means that human actions have not had a significant net impact on those events and circumstances and, as a result, the resulting emissions (and subsequent CO_2 removals) resulting from such events and circumstances can thus be considered non-anthropogenic. Thus, the ERT compared the Party's definition of natural disturbances with the IPCC definition and cannot conclude, based on the evidence provided, that a 20 per cent threshold is consistent with the definition of natural disturbances provided in the 2019 Refinement to the 2006 IPCC Guidelines (vol. 4, chap. 2.6.1.2), nor that all stand-replacing disturbances have a natural disturbance component only. This is because the Party's 20 per cent mortality threshold has been set without being based on evidence, such as a statistical analysis of disturbances over a historical period, to support it. The mortality threshold used by Canada cannot distinguish the emissions and removals beyond the control of a country and those that occur because of the ordinary dynamic between human actions and natural factors, such as forest growth and natural mortality. During the review, the Party clarified that the aim of the 20 per cent threshold applied, together with the other criteria, is to ensure that GHG emissions and removals reported in the inventory are those resulting predominantly from management activities associated with wood production. The Party underlined its obligation to provide unbiased information on anthropogenic emissions and removals to national policymakers. Nevertheless, the Party indicated that the threshold is a pragmatic one based on expert judgment rather than a statistical determination of outlier events that are out of the control of the country. The ERT noted that the 2006 IPCC Guidelines recognize that GHG emissions and removals from managed lands are the dominant result of human activity, and so can provide for an accurate assessment of the impact, in terms of GHG emissions and removals, of human activities and their trend over time. Nonetheless, the 2006 IPCC Guidelines (vol. 4, chap. 1, p.5) consider that although the natural background of GHG emissions and removals by sources and sinks tends to average out over time and space, natural events (e.g. stand-replacing disturbances by natural agents) can have substantial impacts on the annual total anthropogenic net emissions from managed lands reported in an inventory time series. As such, the 2019 Refinement to the 2006 IPCC Guidelines (vol. 4, chap. 2, pp.17–72) provides additional good practice to separate the total emissions and removals estimated from managed forest land into two subcomponents: those emissions and removals considered to result from human activity and those that are understood to result from natural disturbances. The ERT therefore emphasizes that the IPCC provides a disaggregation method for an accurate reporting of anthropogenic emissions and removals from forest land in the inventory, giving policymakers and other users of the inventory relevant unbiased information on the status and trends of anthropogenic GHG emission and removals from forest land. The ERT considers that the scientific studies that the Party cited do not confirm that the country's approach to identifying natural disturbances is consistent with the generic definition of natural disturbances provided in the 2019 Refinement to the 2006 IPCC Guidelines (vol. 4, chap. 2.6.1.2) (i.e. non-anthropogenic events or non-anthropogenic circumstances that cause significant emissions that are beyond the control of the country and are not materially influenced by the Party).	

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The ERT recommends that the Party revise its approach to estimating and disaggregating natural disturbance emissions and removals. Given that the Party justifies its approach by referring to the 2019 Refinement to the 2006 IPCC Guidelines (NIR part 1, p.180), the ERT suggests that the Party revise its definition of natural disturbances such that it is fully consistent with the definition in the 2019 Refinement to the 2006 IPCC Guidelines (vol. 4, chap. 2.6.1.2). The ERT also suggests that the Party revise its identification of natural disturbances according to the definition of natural disturbance in the 2019 Refinement to the 2006 IPCC Guidelines (vol. 4, chap. 2.6.1.2), limiting the natural disturbance emissions and subsequent removals to those caused by non-anthropogenic events or exacerbated by non-anthropogenic circumstances that are beyond the control of, and not materially influenced by, the Party.

In response to this ERT finding and the associated recommendation, Canada, in its comments on the draft review report, indicated that it maintains the position that wildfire is and has been for millenniums a natural part of the ecosystem functions of the forest land that falls within its borders and that, as such, forest management in Canada does not and has never attempted to maintain zero fires as a management objective, as may be the case in some more densely populated countries with small, heavily managed forest land areas.

Further, Canada noted that the 2019 Refinement to the 2006 IPCC Guidelines state that the assumption of net neutrality of human impact cannot be made unless evidence is provided, and that it provided evidence to support this assumption. The Party highlighted that while the Parisien et al. (2016) study is a broad North American analysis, the studies presented by Canada were more recent and specific to Canadian ecosystems. The importance of studies centred on Canadian ecosystems is addressed in the Parisien et al. (2016) study where the authors say (p.11), “fire is as variable as the biophysical environment that defines it”, emphasizing the importance of country-specific information. It is Canada’s position that the Parisien study is too heavily influenced by data from the United States to be directly applicable to Canada; the studies that are cited in Canada’s NIR more accurately represent Canadian conditions and those demonstrate that there is no net positive or negative impact of anthropogenic interventions on burned area.

(b) **Imbalance between disaggregated natural disturbance emissions and subsequent removals and inclusion of anthropogenic emissions/removals.** The Party reported in its NIR (part 2, annex 3, p.161) that emissions and removals are identified (and thus disaggregated) as resulting from natural disturbances when they originate from stands that have been affected by (1) a stand-replacing natural disturbance up to the period that they reach commercial maturity or (2) a partial disturbance (greater than 20 per cent mortality of the standing biomass stock) resulting in reduced standing biomass until that stand has attained biomass equivalent to pre-disturbance values.

The ERT noted that such an approach is not built on the expectation that, for natural disturbances, disaggregated CO_2 emissions and subsequent CO_2 removals average out across time (also known as equivalence, that is, that natural disturbance CO_2 emissions equal CO_2 removals across time). Consistently with the managed land proxy, equivalence is expected to be achieved at the level of CO_2 emissions and removals, not at the level of pre-disturbance carbon stocks. In the case of pest disturbances, the exclusion of forest land until it recovers to pre-disturbance biomass carbon stocks can mean that these lands are excluded beyond the time when CO_2 emissions and subsequent CO_2 removals have cancelled one another out. This is because after pest disturbances, regeneration occurs and forest regrowth soon offsets the initial emissions and the lagged emissions that continue to occur. This ultimately means that the Party’s approach disaggregates (and excludes from the inventory’s total net

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		emissions) more subsequent CO_2 removals than the CO_2 emissions from natural disturbances (i.e. in this case the Party's inventory estimates do not consider all the removals). During the review, the Party indicated that it was working on developing improved models that will be capable of estimating a growth response to a partial disturbance, which means that the models will be capable of identifying the fraction of resident carbon stocks oxidized because of natural disturbances from the fraction oxidized because of a disturbance by human activities. In contrast, for wildfires the Party applies the aggregated total carbon stock across all carbon pools before disturbances as the parameter to check the equivalence between CO_2 emissions and subsequent CO_2 removals and it is assumed that when the biomass stock has reached commercial maturity the aggregated total carbon stock across all carbon pools is equivalent to that of the forest before the disturbance. The Party provided the ERT with a diagram showing the ratio between the pre-disturbance total carbon stock and the total carbon stock at the age of commercial maturity. The ERT noted that small differences in the ratio can correspond to large differences in CO_2 fluxes (emissions and removals) given that the fluxes caused by the natural disturbances are a fraction of the aggregated total carbon stock across all carbon pools in a forest stand. The ERT also noted that, as per forest management practices in the country, forest land affected by stand-replacing disturbances is often subject to operations to assist the regeneration of tree cover that cause further, yet now anthropogenic, carbon losses whose subsequent, and anthropogenic, carbon stock gains associated with forest regrowth are being instead disaggregated as associated with natural disturbances, which allows a systematic underestimation of anthropogenic CO_2 removals from the national total net emissions. This is because the Party's equivalence between CO_2 emissions and removals associated with the natural disturbance is made at the level of the total ecosystem carbon stock level rather than at the level of CO_2 fluxes. This again leads to a failure to ensure the expectation that disaggregated CO_2 emissions and subsequent CO_2 removals average out across time is met, and indeed the 2019 Refinement to the 2006 IPCC Guidelines (vol. 4, chap. 2.6) does not provide a time limit for the above expectation because the time to reach the balance depends on the types of ecosystem affected by disturbances and their rates of regrowth. The Party also clarified during the review that it does not have data on the quantity of carbon that was burned in wildfires prior to 1990. According to the guidance in the 2019 Refinement to the 2006 IPCC Guidelines (vol. 4, chap. 2.6), if it is not possible to estimate directly the amount of emissions that need to be balanced, for example if natural disturbances occurred before the reporting period, the time needed to reach a balance can be approximated on the basis of the estimated length (years) of the recovery period. As indicated in Kurz et al. (2018), the average age of Canadian forests that were burned by wildfires from 1990 to 2016 was 74.9 years, while the average age of the burned areas was 84.3 years. The Party stressed that it is important to recognize that the approach is intended to function at the landscape scale and not at the individual land parcel scale, as it is understood that the objectives of management are applied to the landscape and the treatment of individual parcels may differ in order to achieve the overall landscape management objectives. The ERT noted that the estimated length (years) of the recovery period in the 2019 Refinement to the 2006 IPCC Guidelines refers to the time a stand needs to fully recover its carbon stocks to the pre-disturbance level (i.e. the time taken for natural disturbance CO_2 emissions to be balanced by subsequent removals), not to the maturity of a stand for commercial use. Such length (years) of the recovery period to be applied to the stand subject to pre-1990 natural disturbances can be estimated as the average period across which the Party's model (CBM-CFS3) estimates net accumulation of carbon stocks up to their pre-disturbance level for post-1989 natural disturbances. The ERT also noted that the amount of CO_2 emissions associated with pre-1990 disturbances can be inferred using the	

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estimates produced for disturbed lands in the 31-year period reported in the inventory (1990–2021) and thus used to establish the residual amount of subsequent CO_2 removals expected to be disaggregated in the inventory time series. Regarding the application of the IPCC methodology, the Party commented during the review that potential changes in fire intensity over time and the accuracy of model simulations of fire intensity introduce significant uncertainty to this calculation.

The ERT recommends that the Party:

(a) Conduct and report in the NIR on a quantitative analysis of disaggregated CO_2 emissions reported as associated with natural disturbances at their occurrence, excluding any subsequent C loss associated with forest operations (salvage logging, land clearing and replanting), and of subsequent CO_2 removals up to the maturity level for each combination of forest type and administrative region modelled in the inventory;

(b) Provide in the NIR information demonstrating that the identification (and disaggregation) of natural disturbance events is consistent with IPCC good practice and the requirements of the UNFCCC Annex I inventory reporting guidelines, by including information that demonstrates that carbon stock losses caused by the harvest and/or land clearing before replanting as well as subsequent carbon stock gains due to forest regrowth for an amount equivalent to those stock losses are reported in the inventory as resulting from human activities and thus are excluded from the assessment of equivalence between disaggregated CO_2 emissions and CO_2 removals;

(c) Revise its approach for estimating and disaggregating natural disturbance emissions and removals to make it consistent with IPCC good practice and the requirements of the UNFCCC Annex I inventory reporting guidelines, given that the approach applied, which is inconsistent with the managed land proxy, is not built on the expectation that CO_2 emissions from natural disturbances and associated subsequent removals average out across time. Given that the Party justifies its approach by referring to the 2019 Refinement to the 2006 IPCC Guidelines (NIR part 1, p.180), the ERT suggests that the Party revise its approach so that it is fully consistent with the definition of natural disturbances and good practice in the 2019 Refinement to the 2006 IPCC Guidelines (vol. 4, chap. 2, pp.67–71). The revised approach should ensure that the expectation that the CO_2 emissions and subsequent CO_2 removals of the natural disturbance component cancel out over time is met;

(d) Ensure the expected equivalence between disaggregated emissions and subsequent removals by comparing the estimated fluxes qualified as natural disturbances of CO_2 emissions and subsequent CO_2 removals from forest land instead of comparing pre- and post-disturbance carbon stocks over the recovery period. The ERT noted that a fraction of that pre-disturbance carbon stock is likely to be lost owing to human activities at some point after the disturbance, for example site clearing before replanting, and this would ultimately provide for accurate estimates of anthropogenic and natural components of forest land CO_2 emissions and removals, and likely for larger anthropogenic sinks reported under category 4.A forest land.

In response to this ERT finding and the associated recommendations, Canada, in its comments on the draft review report, indicated that, in reference to Kurz et al. (2018), the peer-reviewed publication documenting the Canadian approach, the basis of the use of the commercial maturity criteria is that commercial maturity is functionally equivalent to the estimated average age of forests burned during the reporting period in Canadian forests and is used as a proxy for carbon equivalency. The Party also indicated that, according to the guidance in the 2019 Refinement to the 2006 IPCC Guidelines (vol. 4, chap. 2.6), if it is not possible to estimate directly the amount of emissions that need to be balanced, for example if natural disturbances occurred before the reporting period, the time needed to reach a balance can be approximated on the basis of the estimated length (years) of the recovery

ID#	Finding classification	Description of finding with recommendation or encouragement	Is finding an issue?[a]
		period (see, e.g., box 2.2j in the above-mentioned guidelines), that is, estimated through a proxy. The Party noted that box 2.2j in the guidelines describes Canada's approach. This aspect of the guidance clearly indicates that when historic carbon disturbance quantities are unknown, proxies for carbon equivalency can be used. Regarding revising its approach to one that could be used to estimate expected equivalence between disaggregated emissions and subsequent removals, as this approach would be based on long-term model projections, it is Canada's position that it is unlikely to produce estimates that are more accurate than the current estimates and therefore would not likely better assure carbon equivalency. The Party suggested that this approach would be a potential quality control or independent validation procedure as opposed to a methodological approach. However, it acknowledged that improvements to the approach and transparency of communication of the methodology would be helpful. Canada will continue to produce and continuously improve its method for quantifying anthropogenic impacts to Canadian forest carbon to ensure they are representative of Canadian sustainable forest management practice and that conformity with IPCC good practice is effectively communicated.	
L.23	4.B Cropland – CO_2, N_2O	The Party reported in its NIR (part 1, p.194) that for SOC changes in mineral soils in cropland, "the validity of the Census-of-Agriculture-based land management changes estimates relies on two key assumptions: the additivity and reversibility of area-based carbon factors". Accordingly, SOC changes associated with tillage intensity, crop residues and manure addition to soils are estimated separately by applying different methods, with the results being summed for a total net change. The ERT noted that while the reversibility is consistent with the IPCC good practice method for estimating SOC changes, the additivity assumption (NIR part 2, p.174; carbon changes from each individual land management change occurring on the same piece of land are assumed independent, and thus the total impact is estimated by adding each of the single impacts) is not fully equivalent with the good practice set out in the 2006 IPCC Guidelines (vol. 4, chap. 2, equation 2.25) for determining SOC changes in mineral soils. Indeed, the good practice in the 2006 IPCC Guidelines estimates the combined effect of changes of multiple variables through a multiplicative propagation of their expected impacts, that is, SOC_{REF} multiplied by all CSC factors (i.e. $SOC_{REF} \times F_{LU} \times F_{MG} \times F_I$), which provides for a cumulative effect that is smaller than just summing the impacts of the variables estimated singularly, that is, SOC_{REF} multiplied by each CSC factor separately and summing the three results (i.e. $SOC_{REF} \times F_{LU} + SOC_{REF} \times F_{MG} + SOC_{REF} \times F_I$). During the review, the Party clarified that its methodology does indeed consider that management factors are additive rather than multiplicative, as per the default method in the 2006 IPCC Guidelines (vol. 4, chap. 2, equation 2.25). The Party provided further details of its country-specific method, which uses both models (e.g. Century) and tier 2 methods from the 2019 Refinement to the 2006 IPCC Guidelines (vol. 4, chap. 5.2.3.2) to derive country-specific management factors. The country-specific method also uses a reference soil level associated with intensive tillage, and in this context, the Party explained its view that the multiplicative approach of the tier 2 method would significantly overestimate the impacts of improved soil management. The Party provided copies of relevant journal papers describing the methodology, as well as the agreement between simulated and observed SOC stock changes in cropland (e.g. Liang, Padbury and Patterson, 2004). The Party also presented ongoing work to implement an improved, integrated modelling approach in the near future that will address interactions among different variables in determining the level and trend in SOC. The ERT concludes that the methodology is not consistent with the default approach in the 2006 IPCC Guidelines (vol. 4, chap. 2, equation 2.25) and is in fact a country-specific method. The ERT also concludes that such an	Yes. Transparency

ID#	*Finding classification*	*Description of finding with recommendation or encouragement*	*Is finding an issue?*[a]
		approach, whereby management-induced gains and losses are added together, may, under a combination of large individual management-induced changes, lead to SOC results that are not physically constrained (e.g. the sum of large CSCs may exceed the carrying capacity). Nonetheless, the ERT also notes that the methodology, whereby the factors are derived by applying tier 3 models, as well as tier 2 methods from the 2019 Refinement to the 2006 IPCC Guidelines, reproduces with confidence the observations of non-linear changes in cropland SOC caused by changes in management. The ERT acknowledges that where the management-induced changes are small or moderate, similar results to the multiplicative approach of the IPCC can be achieved. The ERT recommends that the Party report in the NIR sufficient information on the country-specific approach, in particular observational data verifying the model results for combined management factors. The ERT encourages the Party to continue with efforts to develop and implement the integrated approach to estimate SOC changes in mineral soils in cropland that was presented to the ERT during the review.	
L.24	4.B Cropland – CO_2	The Party reported an area of organic soils under cropland of 16.15 kha across the entire time series in CRF table 4.B. The ERT noted that FAOSTAT provides an estimate of the area of organic soils under agricultural use of 1,372.3 kha. During the review, the Party provided a list of contact people across provinces and territories tasked with reporting on the cultivation of organic soils. The ERT encourages the Party to investigate additional sources of information to confirm the area of organic soils reported under cropland given the large difference and given that peatlands cover 13 per cent of the land area (Tarnocai, Kettles and Lacelle, 2011), although 97 per cent of that is in the boreal and subarctic regions, and thus not suitable for agricultural use.	Not an issue
L.25	4.B.2 Land converted to cropland – CO_2	Although the Party reported AD and biomass losses in forest land and grassland converted to cropland, it reported biomass gains as "NO" in CRF table 4.B. The ERT noted that the 2006 IPCC Guidelines (vol. 4, chap. 5, table 5.9) provide default values for biomass carbon stock in cropland, for both annual cropland and perennial cropland. During the review, the Party clarified that the productivity of agricultural grassland is very low. Bailey and Liang (2013) reported that the average above-ground biomass is 1,100 kg/ha on brown chernozem soils and 1,700 kg/ha on dark brown chernozem soils. The respective grain yield of wheat is approximately 1,600 kg/ha or 3,600 kg dry matter/ha for brown chernozem soils and 1,800 kg/ha or 4,000 kg dry matter/ha for dark brown chernozem soils (Liang et al., 2005). Thus, the above-ground biomass for agricultural grassland is generally lower than its yield under crop production. It is likely that there is, however, greater below-ground biomass, which is likely to make the total living biomass roughly equivalent, although the quantity of below-ground biomass is highly uncertain. As such, the Party concluded that it is not possible to determine with adequate certainty that there is in fact a change in standing biomass, and consequently the assumption of biomass equivalence was applied. However, the ERT noted that the average resident biomass carbon stock of a crop does not correspond to the annual yield, given that it would be calculated as the average of the daily/monthly resident carbon stock across the year. For example, assuming a six-month linear growth for wheat and a barren soil/soil covered by snow for the remaining six months, 4,000 kg dry matter/ha would correspond to an average annual biomass stock of 500 kg dry matter/ha/year. The ERT recommends that the Party calculate biomass carbon stock gains in forest land converted to cropland and grassland converted to cropland by using the default methodology in the 2006 IPCC Guidelines (vol. 4, chap. 5,	Yes. Completeness

ID#	Finding classification	Description of finding with recommendation or encouragement	Is finding an issue?[a]
		table 5.9) and default values when no better data are available in the country and explain this recalculation in the NIR.	
L.26	4.E Settlements – CO_2	The Party reported in its NIR (part 1, p.206) that the estimated total crown cover area was multiplied by a crown cover area based growth rate (as defined in the 2006 IPCC Guidelines (vol. 4, chap. 8, equation 8.2)) specific to each reporting unit to yield an annual gross sequestration rate; the net sequestration was estimated by applying a factor to the gross value. The ERT noted that this is not in accordance with the 2006 IPCC Guidelines (vol. 4, chap. 8, equation 8.2) because the calculation of net accumulation of biomass is not limited to the AGP (the IPCC default length is 20 years; thereafter, the method assumes that the accumulation of carbon in biomass slows with age, and thus for trees older than the AGP, increases in biomass carbon are assumed to be offset by losses from pruning and mortality, which means ΔC_G for wood equals ΔC_L for wood). The ERT noted that by estimating an indefinite net accumulation of biomass, the Party introduced a systematic overestimation (bias) of the actual sink in settlements. During the review, the ERT raised this accuracy issue and the Party provided a paper describing how the i-Tree Eco model was implemented to derive the net CSC factors for the inventory (Steenberg et al., 2023). The Party elaborated on the fraction of gross CO_2 sequestration that is lost by mortality, harvest, pruning and litter turnover, and defined the fraction of biomass losses that flow into the fuelwood subpool of HWP, which is consistent with other countries with similar urban areas. Despite the clarifications provided, the ERT noted that the indefinite application of these net CSC factors to settlements substantially overestimates the net CO_2 sequestration by settlement biomass. The ERT also noted that according to values provided in table 5 of Steenberg et al. (2023), the national average resident biomass stock in settlements (27,297.80 kt C) would be achieved with the national average net CSC applied in the inventory (1,121.70 kt C/year) within 24.3 years, assuming a starting stock of 0 kt C. The ERT recommends that the Party set an AGP and accordingly estimate the net accumulation of biomass from the year Y in which the trees are planted and the year Y + AGP in which the biomass of trees is assumed to have carbon stock gains equivalent to carbon stock losses (i.e. ΔC_G for wood equals ΔC_L for wood). Noting that these gains in settlement biomass are only reported under settlements remaining settlements, yet acknowledging planned improvements to this issue, the ERT also recommends that Canada partition these total settlement gains between settlements remaining settlements (category 4.E.1) and land converted to settlements (category 4.E.2). The ERT encourages the Party to revisit the model assumptions on which losses are included in the net carbon sequestration factor derived from the i-Tree Eco model and to verify that all relevant stock losses are included and report on such verification.	Yes. Accuracy
L.27	4.G HWP – CO_2	The Party reported in its NIR (part 1, p.187) that the annual net CSC in the HWP category is estimated by applying the simple decay approach described in the 2006 IPCC Guidelines (vol. 4, annex 12A, chap. 12). However, the ERT noted that Canada reports (–44/12 × annual carbon domestic harvest) as part of the agriculture, forestry and other land use land area (forest land, cropland, wetlands and settlements, see issue ID# L.15 above) and the annual HWP contribution as the gross CO_2 release from HWP (44/12 × annual release of carbon to the atmosphere from HWP that came from wood harvested in the reporting country, including wood that is exported but excluding imports).	Yes. Accuracy

ID#	*Finding classification*	*Description of finding with recommendation or encouragement*	*Is finding an issue?*[a]
		During the review, the Party noted that this issue is related to the exclusion of biomass losses associated with the wood harvested and extracted from categories 4.A forest land, 4.B cropland, 4.D wetlands and 4.E settlements, as explained in ID# L.15 above. In addition, the Party provided the ERT with additional information on the equations applied to estimate the annual HWP contribution. The ERT concludes that the Party is reporting with the annual HWP contribution: (a) Gross carbon stock losses associated with the production and use in other countries of HWP produced from roundwood exported by Canada in those other countries; (b) All gross carbon stock losses of domestically harvested roundwood not transformed into HWP, for example all fuelwood and milling residues; (c) Gross carbon stock losses from the four HWP subpools (sawnwood, panels, pulp and paper, other industrial roundwood), while the annual carbon inflow (i.e. the gross gain) of each of those subpools is not included). This means that the annual HWP contribution reported is the gross annual carbon losses from the HWP pool instead of the net CSC, as required by IPCC good practice. On the basis of this additional information, the ERT concluded, regarding (a) above, that the boundary of a Party's inventory is limited to the HWP produced in the country, so this extension of the boundaries of the HWP pool needs to be justified by the Party. Regarding (b) and (c) above, the ERT noted that the IPCC general approach to estimate annual net CO_2 emissions/removals from each carbon pool requires estimating all carbon stock gains and losses in the year, or just the net result of all carbon stock gains and losses occurring in the year in the resident carbon stocks of the HWP pool, so the reporting of only the gross carbon stock loss is not consistent with IPCC good practice. Consequently, the annual HWP contribution calculated by the Party is a systematic overestimation of the net annual CO_2 emissions from the HWP carbon pool. Indeed, in some years the HWP carbon stock may in fact be increasing (i.e. contributing as a sink to the LULUCF sector); however, this is masked by reporting only the CO_2 emissions from the gross losses of carbon. Given the magnitude of inflows associated with timber harvest, the omission of these gains in the HWP category constitutes a substantial completeness issue that de facto constitutes a comparability issue at the level of the HWP category. The ERT recommends that the Party recalculate the HWP annual contribution consistently with the IPCC simple decay approach as –44/12 × (annual carbon domestic harvest – annual release of carbon to the atmosphere from HWP that came from wood harvested in the reporting country, including wood that is exported but excluding imports) by applying all relevant variables associated with carbon stock gains and losses that occurred in the year in the resident carbon stocks of the HWP pool as provided in table 12A.1 of the 2006 IPCC Guidelines (vol. 4, annex 12A, chap. 12, p.31) (noting the typographical error in the 2006 IPCC Guidelines in which the table is referred to as "Table A12.1") or table 12A.1 in the 2019 Refinement to the 2006 IPCC Guidelines (annex 12A to vol. 4, chap. 12, p.47), and by excluding the stock losses associated with the production and use in other countries of HWP produced from unmanufactured roundwood exported by Canada in those other countries.	
L.28	4.G HWP – CO_2	The Party reported in its NIR (part 2, annex 3, pp.169–172) that harvested quantities of roundwood, including industrial roundwood and any fuelwood, used in the model to calculate the annual net CSC in the HWP pool are modelled by CBM-CFS3 and spatialized among the reporting units on the basis of current management practices	Yes. Transparency

ID#	Finding classification	Description of finding with recommendation or encouragement	Is finding an issue?[a]
		and the age structure of modelled forests, but did not provide information on the verification of modelled harvest quantities in and across the relevant land categories. The ERT noted that this is not in accordance with the good practice in the 2006 IPCC Guidelines (vol. 4, chap. 2.5.2), which requires the verification of a tier 3 model's outputs through a comparison with independent data. During the review, the Party provided the additional information that NFCMARS imports data from Canada's National Forestry Database for commercial roundwood harvest targets and that CBM-CFS3 implements 100 per cent of those targets as actual harvest in its simulation of annual net CSCs in each carbon pool. The resulting harvested carbon is transferred to NFCMARS as commercial harvest inflow. The Party also provided a figure on a preliminary comparison between modelled data and FAOSTAT statistics on industrial roundwood only, given that a thorough comparison would require weeks to be completed. Nonetheless, the comparison provided shows a good degree of correspondence. The ERT noted that information verifying the quality of the model's outputs is not provided in the NIR. The ERT recommends that the Party provide in the NIR information on the verification of the simulated HWP inflows by including a comparison between modelled data and independent data collected from national economic statistics (a comparison with data from FAOSTAT could be considered for this purpose) for each of the following variables: annual harvested quantities of industrial roundwood and fuelwood, and the production of each of the HWP. Noting the in-depth discussions on NFCMARS during the review and the identification of missing representations of some model subpools and flows (e.g. exported roundwood) in figure A3.5–8 in annex 3 to the NIR, the ERT also recommends that the Party provide additional detailed descriptions of all modelled pools and flows in the model, as well as the respective equations used to model the inflows and outflows between pools and then to the atmosphere.	
Waste			
W.9	5.A.2 Unmanaged waste disposal sites – CH_4	The Party reported inconsistent methane correction factor values for unmanaged waste disposal sites (for solid wood waste) between CRF table 5.A (methane correction factor of 0.92) and NIR table A3.6-9 (part 2, p.218) (methane correction factor of 0.8). During the review, the Party clarified that the value in the NIR (0.8) was used in the calculations, which is the intended value derived from the 2006 IPCC Guidelines default methane correction factor value for unmanaged deep SWDS (vol. 5, chap. 3, table 3.1). As such, this issue has no impact on the reported emissions. The ERT recommends that the Party correct the reported methane correction factor value for unmanaged SWDS in CRF table 5.A.	Yes. Convention reporting adherence
W.10	5.B.1 Composting – CH_4 and N_2O	The Party reported in its NIR (part 2, p.219) that CH_4 and N_2O emissions from home composting are not included in the Canadian inventory at this time owing to a lack of available data. The ERT noted that survey data related to home composting appeared to be available on the Statistics Canada website. During the review, the Party clarified that Statistics Canada's table 38-10-0128-01 ("Composting practices of Canadian households"), available on Statistics Canada's website, only tracks the number of households that home compost and not the tonnage of waste used in home composting. The Party indicated that it plans to incorporate home composting in its future submissions. In addition, the Party provided a calculation using AD of 4 kg of waste used in home composting per week per household. This value is the upper range identified in a study of Danish	Yes. Completeness

ID#	*Finding classification*	*Description of finding with recommendation or encouragement*	*Is finding an issue?*[a]
		households (1–4 kg). On this basis, the Party provided a preliminary estimate of its 2021 emissions for home composting in Canada (80.3 kt of CO_2 eq, or 0.01 per cent of Canada's national emissions in 2021), which is below the significance threshold established in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines. However, the ERT noted that the significance threshold applies at the category level, not to a part of a category, and concludes that those emissions should be estimated. The ERT recommends that the Party estimate and report emissions from home composting as part of the emissions for category 5.B.1 and explain the recalculation in the NIR.	
W.11	5.D.1 Domestic wastewater – CH_4 and N_2O	The Party reported in its NIR (part 2, p.229, notes under equation A3.6-16) that it applies the 2006 IPCC Guidelines default correction I-factor of 1.25 (vol. 5, chap. 6, p.13) for additional industrial BOD discharged into sewers. The ERT noted that the use of the I-factor is often not applicable to certain treatment pathways such as septic systems that may only gather and treat wastewater from domestic sources. During the review, the Party clarified that it applies the correction factor for additional industrial BOD discharged into sewers to its estimates for all domestic wastewater treatment systems, including septic systems. The Party explained that this method is implemented owing to the use of communal septic systems in rural and remote locations into which industrial and commercial facilities may discharge. The ERT recommends that the Party include an explanation for its application of the default correction factor for additional industrial BOD discharged into sewers (1.25) across all of its domestic wastewater treatment systems (including septic tanks) in the NIR.	Yes. Transparency
W.12	5.D.2 Industrial wastewater – CH_4 and N_2O	The Party reported in CRF table 5.D a significant trend increase in its CH_4 emissions for category 5.D.2 industrial wastewater of 440 per cent between 2012 and 2013 (from 127 kt CO_2 eq in 2012 to 687 kt CO_2 eq kt in 2013), without explaining the change in the NIR. During the review, the Party clarified that it identified errors in its calculations that led to, and exacerbated, the jump in emissions seen in 2010–2015 for CH_4 from industrial wastewater. Two specific errors were identified in the calculations: the time-series completion (extrapolation) was not properly applied and a programming join error appeared to have caused some cases of double counted emissions. The Party provided the ERT with provisional estimates that recalculated the time series for both CH_4 and N_2O from industrial wastewater. The revised calculations indicated that the emissions are lower than reported in the 2023 NIR for 2013 and later and that the time-series jump remains but is significantly more modest in nature (e.g. total CH_4 and N_2O emissions from category 5.D.2 industrial wastewater estimated as approximately 420 kt CO_2 eq in 2010 increase to approximately 497 kt CO_2 eq in 2015). The ERT recommends that the Party correct the errors identified in the estimates for the time series for emissions of CH_4 and N_2O from industrial wastewater (category 5.D.2 industrial wastewater) and describe the rationale and impact of its recalculation(s) in the NIR.	Yes. Accuracy
W.13	5.E Other (waste) – CO_2	The Party reported in CRF table 5 non-biogenic CO_2 emissions from industrial wastewater under category 5.E other, with an explanation in the documentation box that "only non-biogenic CO_2 emissions are reported for industrial wastewater under 5.E., all other information is reported under 5.D.2". The ERT noted that methodologies to estimate non-biogenic CO_2 emissions from wastewater treatment and discharge are not provided in the 2006 IPCC Guidelines (vol. 5, chap. 6.1, p.6.6) as CO_2 emissions "are of biogenic origin and should not be included in	Yes. Transparency

ID#	Finding classification	Description of finding with recommendation or encouragement	Is finding an issue?[a]
		national total emissions". The Party does not describe the source of or methodology for its non-biogenic CO_2 emissions in its NIR. During the review, the Party clarified that non-biogenic CO_2 emissions from industrial wastewater are reported by facilities. These tend to be from industries that process fossil-based liquids, such as refineries and chemical manufacturing, or occasionally from fossil-based substances added to wastewater as part of the treatment process. The Party reported the non-biogenic CO_2 emissions in CRF table 5 using category 5.E other because there was no place in CRF table 5.D.2 to include non-biogenic CO_2. The ERT recommends that the Party include in its NIR a description of non-biogenic CO_2 emissions from industrial wastewater facilities in Canada, including the methodologies applied, and how emissions are allocated in its CRF tables.	

[a] Recommendations made by the ERT during the review are related to issues as defined in para. 81 of the UNFCCC review guidelines.

Annex I

Overview of greenhouse gas emissions and removals as reported by Canada in its 2023 inventory submission

Tables I.1–I.3 provide an overview of the total GHG emissions and removals as reported by Canada.

Table I.1
Total greenhouse gas emissions and removals for Canada, 1990–2021
(kt CO_2 eq)

	Total GHG emissions excluding indirect CO_2 emissions		*Total GHG emissions and removals including indirect CO_2 emissions*[a]	
	Total including LULUCF	*Total excluding LULUCF*	*Total including LULUCF*	*Total excluding LULUCF*
1990	524 095.80	588 602.82	524 785.58	NA
1995	596 703.34	639 070.29	597 506.90	NA
2000	681 687.00	719 463.71	682 389.42	NA
2010	683 694.55	701 867.55	684 312.24	NA
2015	722 942.17	722 918.27	723 684.81	NA
2020	645 400.71	658 788.39	645 867.74	NA
2021	653 125.73	670 428.30	653 613.44	NA

Note: Emissions and removals reported for the sector other (sector 6) are not included in the total GHG emissions.
[a] The Party reported indirect CO_2 emissions in CRF table 6.

Table I.2
Greenhouse gas emissions and removals by gas for Canada, excluding land use, land-use change and forestry, 1990–2021
(kt CO_2 eq)

	CO_2[a]	*CH_4*	*N_2O*	*HFCs*	*PFCs*	*Unspecified mix of HFCs and PFCs*	*SF_6*	*NF_3*
1990	458 503.10	83 913.85	34 431.19	970.54	7 557.90	NA, NO	3 225.92	0.32
1995	491 825.70	100 379.04	37 782.67	460.51	6 346.94	NA, NO	2 275.16	0.28
2000	567 096.10	110 824.42	30 900.64	2 754.84	4 984.51	NA, NO	2 902.96	0.24
2010	556 062.10	107 761.32	28 006.42	7 729.05	1 861.28	NA, NO	447.22	0.15
2015	570 680.33	109 975.16	29 778.17	11 041.05	976.68	NA, NO	466.87	0.01
2020	522 845.30	91 379.82	31 523.43	11 918.85	828.56	NA, NO	291.81	0.62
2021	537 173.74	90 509.76	30 231.40	11 433.41	752.88	NA, NO	326.50	0.62
Percentage change 1990–2021	**17.2**	**7.9**	**–12.2**	**1 078.0**	**– 90.0**	**NA**	**–89.9**	**89.8**

Note: Emissions and removals reported for the sector other (sector 6) are not included in this table.
[a] Totals do not include indirect CO_2 emissions reported in CRF table 6 as the Party reported indirect CO_2 emissions in CRF table 6 only for the LULUCF sector.

Table I.3
Greenhouse gas emissions and removals by sector for Canada, 1990–2021
(kt CO_2 eq)

	Energy	*IPPU*	*Agriculture*	*LULUCF*	*Waste*	*Other*
1990	471 564.75	56 965.60	41 139.87	–63 817.24	18 932.61	NA
1995	512 687.70	58 394.40	48 126.20	–41 563.39	19 861.98	NA
2000	593 164.24	54 022.41	50 960.37	–37 074.29	21 316.69	NA
2010	581 702.95	50 576.80	49 517.93	–17 555.30	20 069.86	NA
2015	596 085.21	53 427.35	52 277.46	766.55	21 128.25	NA
2020	531 887.29	50 360.25	55 491.18	–12 920.65	21 049.67	NA
2021	543 183.91	51 943.38	54 243.76	–16 814.86	21 057.25	NA
Percentage change 1990–2021	**15.2**	**– 8.8**	**31.9**	**–73.7**	**11.2**	**NA**

Notes: (1) Canada did not report emissions or removals for the sector other (sector 6); the corresponding cells in the CRF tables were left blank; (2) totals include indirect CO_2 emissions reported in CRF table 6.

Annex II

Additional information to support findings in table 2

Missing categories that may affect completeness

The categories for which estimation methods are included in the 2006 IPCC Guidelines that were reported as "NE" or for which the ERT otherwise determined that there may be an issue with the completeness of the reporting in the Party's inventory are the following:

(a) 2.G.2 SF_6 and PFCs from other product use (PFCs and SF_6) (see ID# I.16 in table 3);

(b) 3.D direct and indirect N_2O emissions from agricultural soils (direct N_2O emissions from compost fertilizer applied to soils) (see ID# A.15 in table 3);

(c) 3.D.b indirect N_2O emissions from managed soils (indirect N_2O emissions from compost fertilizer applied to soils) (see ID# A.16 in table 3);

(d) 4 LULUCF (biomass carbon stocks harvested for the production of HWP for categories 4.A forest land, 4.B cropland, 4.D wetlands and 4.E settlements) (see ID# L.15 in table 5);

(e) 4 LULUCF (land area of unmanaged grassland, unmanaged wetlands, settlements and other land) (see ID# L.2 in table 3);

(f) 4.A.2.1 cropland converted to forest land (biomass pool (CO_2)) (see ID# L.9 in table 3);

(g) 4.B.2 land converted to cropland (biomass carbon stock gains in forest land converted to cropland and grassland converted to cropland (CO_2)) (see ID# L.25 in table 5);

(h) 4.C grassland remaining grassland (mineral soils pools (CO_2)) (see ID# L.1 in table 3);

(i) 4.E grassland converted to settlements (DOM and organic and mineral soils pools (CO_2)) (see ID# L.1 in table 3);

(j) 4.E cropland and wetlands converted to settlements (all pools (CO_2)) (see ID# L.1 in table 3);

(k) 4(III) direct N_2O emissions from N mineralization/immobilization (N_2O) (see ID# L.11 in table 3);

(l) 4(IV) indirect N_2O emissions from managed soils (N_2O) (see ID# L.11 in table 3);

(m) 5.D.2 industrial wastewater (CH_4 and N_2O emissions from the combustion of CH_4 recovered from sewage sludge) (see ID# W.7 in table 3);

(n) 5.B.1 composting (CH_4 and N_2O emissions from home composting) (see ID# W.10 in table 5).

Annex III

Reference documents

A. Reports of the Intergovernmental Panel on Climate Change

IPCC. 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. S Eggleston, L Buendia, K Miwa, et al. (eds.). Hayama, Japan: Institute for Global Environmental Strategies. Available at http://www.ipcc-nggip.iges.or.jp/public/2006gl.

IPCC. 2011. Use of Models and Facility-Level Data in Greenhouse Gas Inventories. *In*: HS Eggleston, N Srivastava, K Tanabe, et al. (eds.). *Report of the IPCC Expert Meeting on Use of Models and Measurements in Greenhouse Gas Inventories.* Hayama, Japan: Institute for Global Environmental Strategies. Available at https://www.ipcc-nggip.iges.or.jp/public/mtdocs/pdfiles/1008_Model_and_Facility_Level_Data_Report.pdf.

IPCC. 2014. *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands*. T Hiraishi, T Krug, K Tanabe, et al. (eds.). Geneva: IPCC. Available at https://www.ipcc.ch/publication/2013-supplement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories-wetlands/.

IPCC. 2019. *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*. E Calvo Buendia, K Tanabe, A Kranjc, et al. (eds.). Geneva: IPCC. Available at https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html.

B. UNFCCC documents

Annual review reports

Reports on the individual reviews of the 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2019 and 2021 inventory submissions of Canada, contained in documents FCCC/ARR/2011/CAN, FCCC/ARR/2012/CAN, FCCC/ARR/2013/CAN, FCCC/ARR/2014/CAN, FCCC/ARR/2015/CAN, FCCC/ARR/2016/CAN, FCCC/ARR/2017/CAN, FCCC/ARR/2019/CAN and FCCC/ARR/2021/CAN respectively.

Other

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C. Other documents used during the review

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