Ministry for the Environment
Manatū Mō Te Taiao

New Zealand's Greenhouse Gas Inventory 1990–2020 Volume 2, Annexes

Fulfilling reporting requirements under the United Nations Framework Convention on Climate Change and the Kyoto Protocol

Te Kāwanatanga o Aotearoa
New Zealand Government

Contents

See volume 1, chapters 1–15, for the National Inventory Report, which is presented separately.

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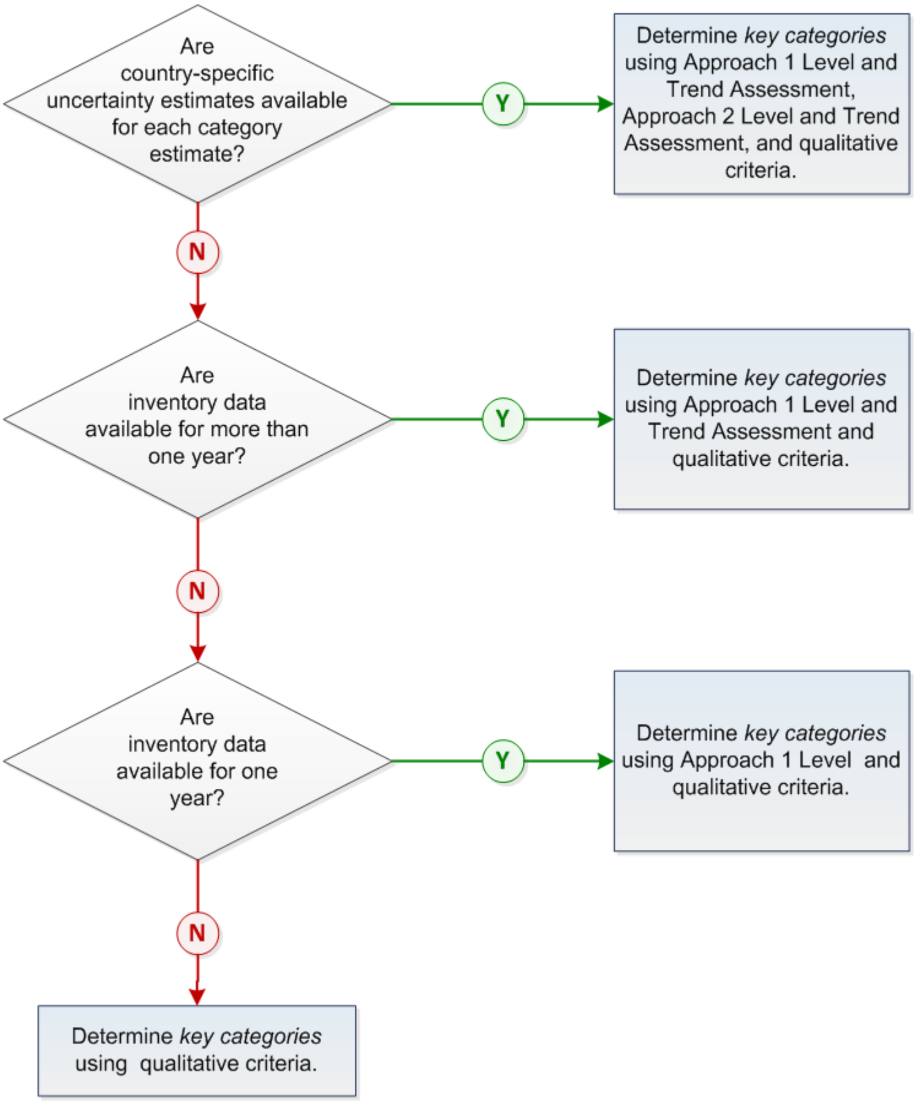
Annex 1: Key categories

A1.1 Methodology used for identifying key categories

The key categories in the inventory have been assessed using Approach 1 level and trend methodologies from the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC, 2006). The methodology applied was determined using the decision tree shown in figure A1.1.1. Approach 1 level and trend methodologies are used because some categories in the inventory apply default uncertainty values for emission estimates. The development of country-specific uncertainty values is resource prohibitive.

Figure A1.1.1 Decision tree to identify key source categories (figure 4.2, IPCC, 2006)



For this inventory submission, Approach 1 level and trend assessments were applied, including and excluding the Land Use, Land-Use Change and Forestry (LULUCF) sector (IPCC, 2006).

The level and trend assessments are calculated as per equations 4.1, 4.2 and 4.3 of the IPCC 2006 Guidelines (IPCC, 2006). Key categories are defined as those categories whose cumulative percentages, when summed in decreasing order of magnitude, contributed 95 per cent of the total level or trend.

A1.2 Disaggregation

The classification of categories follows the classification of the common reporting format (CRF) tables by:

- identifying categories using carbon dioxide equivalent emissions and considering each greenhouse gas from each category separately
- either including or excluding LULUCF categories at the level shown in the IPCC 2006 Guidelines (table 4.1, IPCC, 2006).

The level of aggregation used for the key category analysis is similar to the default aggregation used for the key category analysis within the CRF tables, with adjustments to better reflect New Zealand's emissions profile. Specifically, a large proportion of emissions from the Energy and Agriculture sectors are disaggregated further than the key category analysis generated in the CRF tables, to allow for a more evenly proportioned analysis of categories.

A1.3 Tables 4.2 to 4.3 of the IPCC 2006 Guidelines (General Guidance and Reporting)

The following tables specify the level analyses for 2020 and 1990, and trend analyses, each including and excluding LULUCF. The tables show the categories that comprise 99 per cent of emissions for each analysis. Only the categories that comprise the top 95 per cent of emissions for the 2020 level analysis and the trend analysis are key categories. The 1990 level analysis tables are included for information only.

Table A1.3.1(a) Results of the key category level analysis for 99 per cent of the net emissions and removals for New Zealand in 2020

IPCC Tier 1 category level assessment – including LULUCF (net emissions): 2020					
CRF category code	IPCC category	Gas	2020 estimate (kt CO_2-e)	Level assessment (%)	Cumulative total (%)
4.A.1	Forest Land – Forest Land Remaining Forest Land	CO_2	–15,345.3	14.1	14.1
3.A.1	Option A – Dairy Cattle	CH_4	14,034.7	12.9	26.9
1.A.3.b	Transport – Road Transportation Liquid Fuels	CO_2	11,947.2	10.9	37.9
3.A.2	Other (please specify) – Sheep	CH_4	8,271.2	7.6	45.5
4.G	Land Use, Land-Use Change and Forestry – Harvested Wood Products	CO_2	–6,834.6	6.3	51.7
3.A.1	Option A – Non-Dairy Cattle	CH_4	5,980.9	5.5	57.2
4.A.2	Forest Land – Land Converted to Forest Land	CO_2	–4,638.0	4.3	61.5
3.D.1.3	Direct N_2O Emissions from Managed Soils – Urine and Dung Deposited by Grazing Animals	N_2O	3,890.0	3.6	65.0
1.A.1.a	Energy Industries – Public Electricity and Heat Production Gaseous Fuels	CO_2	2,697.3	2.5	67.5
5.A	Waste – Solid Waste Disposal	CH_4	2,637.7	2.4	69.9
1.A.1.a	Energy Industries – Public Electricity and Heat Production Solid Fuels	CO_2	1,809.3	1.7	71.6

IPCC Tier 1 category level assessment – including LULUCF (net emissions): 2020					
CRF category code	**IPCC category**	**Gas**	**2020 estimate (kt CO_2-e)**	**Level assessment (%)**	**Cumulative total (%)**
1.A.2.e	Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco Solid Fuels	CO_2	1,702.0	1.6	73.1
2.C.1	Metal Industry – Iron and Steel Production	CO_2	1,578.6	1.4	74.6
3.D.1.1	Direct N_2O Emissions from Managed Soils – Inorganic N Fertilizers	N_2O	1,548.2	1.4	76.0
1.A.2.c	Manufacturing Industries and Construction – Chemicals Gaseous Fuels	CO_2	1,540.1	1.4	77.4
2.F.1	Product Uses as Substitutes for ODS – Refrigeration and Air conditioning	HFCs	1,391.6	1.3	78.7
3.B.1.1	Option A – Dairy Cattle	CH_4	1,387.1	1.3	79.9
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing Liquid Fuels	CO_2	1,362.6	1.2	81.2
1.A.4.b	Other Sectors – Residential Liquid Fuels	CO_2	1,313.1	1.2	82.4
4.C.2	Grassland – Land Converted to Grassland	CO_2	1,299.0	1.2	83.6
4.C.1	Grassland – Grassland Remaining Grassland	CO_2	1,225.5	1.1	84.7
1.A.2.e	Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco Gaseous Fuels	CO_2	1,086.7	1.0	85.7
3.D.2.1	Indirect N_2O Emissions from Managed Soils – Atmospheric Deposition	N_2O	925.2	0.8	86.6
1.A.4.a	Other Sectors – Commercial/Institutional Liquid Fuels	CO_2	707.9	0.6	87.2
1.A.3.a	Domestic Aviation – Jet Kerosene	CO_2	681.4	0.6	87.8
3.D.1.6	Direct N_2O Emissions from Managed Soils – Cultivation of Organic Soils	N_2O	667.6	0.6	88.4
2.C.3	Metal Industry – Aluminium Production	CO_2	549.2	0.5	88.9
1.A.1.b	Energy Industries – Petroleum Refining Liquid Fuels	CO_2	543.8	0.5	89.4
3.H	Agriculture – Urea Application	CO_2	542.0	0.5	89.9
3.D.2.2	Indirect N_2O Emissions from Managed Soils – Nitrogen Leaching and Run-off	N_2O	516.9	0.5	90.4
3.A.4	Other Livestock – Deer	CH_4	497.6	0.5	90.9
1.B.2.d	Other (please specify) – Geothermal	CO_2	449.7	0.4	91.3
1.A.2.g.v	Other (please specify) – Construction	CO_2	446.9	0.4	91.7
1.A.4.a	Other Sectors – Commercial/Institutional Gaseous Fuels	CO_2	426.6	0.4	92.1
3.G	Agriculture – Liming	CO_2	409.5	0.4	92.5
1.A.4.b	Other Sectors – Residential Gaseous Fuels	CO_2	388.4	0.4	92.8
2.A.1	Mineral Industry – Cement Production	CO_2	379.2	0.3	93.2
1.A.2.g.iii	Other (please specify) – Mining (excluding fuels) and Quarrying Liquid Fuels	CO_2	365.4	0.3	93.5
4.B.1	Cropland – Cropland Remaining Cropland	CO_2	318.2	0.3	93.8
1.A.2.d	Manufacturing Industries and Construction – Pulp, Paper and Print Gaseous Fuels	CO_2	306.7	0.3	94.1
1.A.3.d	Domestic Navigation – Residual Fuel Oil	CO_2	271.8	0.2	94.3
1.A.1.c	Energy Industries – Manufacture of Solid Fuels and Other Energy Industries Gaseous Fuels	CO_2	263.7	0.2	94.6
3.D.1.4	Direct N_2O Emissions from Managed Soils – Crop Residues	N_2O	258.6	0.2	94.8
5.D	Waste – Wastewater Treatment and Discharge	CH_4	256.9	0.2	95.0
1.B.2.c.1.ii	Venting – Gas	CO_2	256.6	0.2	95.3

IPCC Tier 1 category level assessment – including LULUCF (net emissions): 2020					
CRF category code	IPCC category	Gas	2020 estimate (kt CO_2-e)	Level assessment (%)	Cumulative total (%)
1.A.2.e	Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco Liquid Fuels	CO_2	255.9	0.2	95.5
1.A.2.g.viii	Other (please specify) – Other (please specify) Liquid Fuels	CO_2	212.3	0.2	95.7
1.B.2.b.5	Natural Gas – Distribution	CH_4	192.2	0.2	95.9
1.A.2.f	Manufacturing Industries and Construction – Non-metallic Minerals Solid Fuels	CO_2	178.4	0.2	96.0
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing Solid Fuels	CO_2	171.8	0.2	96.2
1.A.1.b	Energy Industries – Petroleum Refining Gaseous Fuels	CO_2	148.2	0.1	96.3
1.B.2.b.2	Natural Gas – Production	CH_4	141.7	0.1	96.5
2.B.10	Chemical Industry – Other (please specify)	CO_2	134.2	0.1	96.6
4.A	Forest Land – Emissions and removals from drainage and rewetting and other management of organic and mineral soils	N_2O	123.8	0.1	96.7
5.D	Waste – Wastewater Treatment and Discharge	N_2O	120.4	0.1	96.8
1.A.2.a	Manufacturing Industries and Construction – Iron and Steel Gaseous Fuels	CO_2	119.5	0.1	96.9
1.B.2.d	Other (please specify) – Geothermal	CH_4	118.4	0.1	97.0
4.F.2	Other Land – Land Converted to Other Land	CO_2	114.3	0.1	97.1
1.A.3.c	Transport – Railways Liquid Fuels	CO_2	112.9	0.1	97.2
3.B.2.5	N_2O and NMVOC Emissions – Indirect N_2O Emissions	N_2O	100.9	0.1	97.3
1.A.1.a	Energy Industries – Public Electricity and Heat Production Liquid Fuels	CO_2	99.2	0.1	97.4
2.B.8	Chemical Industry – Petrochemical and Carbon Black Production	CH_4	96.1	0.1	97.5
3.B.1.2	CH_4 Emissions – Sheep	CH_4	91.9	0.1	97.6
2.A.2	Mineral Industry – Lime Production	CO_2	91.4	0.1	97.7
5.C	Waste – Incineration and Open Burning of Waste	CO_2	89.8	0.1	97.8
2.C.3	Metal Industry – Aluminium Production	PFCs	87.9	0.1	97.8
3.B.1.1	Option A – Non-Dairy Cattle	CH_4	82.9	0.1	97.9
2.F.4	Product Uses as Substitutes for ODS – Aerosols	HFCs	80.1	0.1	98.0
5.C	Waste – Incineration and Open Burning of Waste	CH_4	77.4	0.1	98.1
4.E.1	Settlements – Settlements Remaining Settlements	CO_2	76.5	0.1	98.1
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing Gaseous Fuels	CO_2	76.5	0.1	98.2
3.D.1.2	Direct N_2O Emissions from Managed Soils – Organic N Fertilizers	N_2O	76.2	0.1	98.3
2.G.3	Other Product Manufacture and Use – N_2O from Product Uses	N_2O	73.9	0.1	98.3
1.A.2.d	Manufacturing Industries and Construction – Pulp, Paper and Print Liquid Fuels	CO_2	68.5	0.1	98.4
2.A.4	Mineral Industry – Other Process Uses of Carbonates	CO_2	66.8	0.1	98.5
4.A.2	Forest Land – Land Converted to Forest Land	N_2O	64.5	0.1	98.5
1.B.1.a.2	Coal Mining and Handling – Surface Mines	CH_4	61.4	0.1	98.6
1.A.3.b	Transport – Road Transportation Liquid Fuels	N_2O	61.1	0.1	98.6
1.A.2.f	Manufacturing Industries and Construction – Non-metallic Minerals Liquid Fuels	CO_2	60.0	0.1	98.7

IPCC Tier 1 category level assessment – including LULUCF (net emissions): 2020					
CRF category code	IPCC category	Gas	2020 estimate (kt CO_2-e)	Level assessment (%)	Cumulative total (%)
1.A.4.a	Other Sectors – Commercial/Institutional Solid Fuels	CO_2	57.7	0.1	98.7
4.B.2	Cropland – Land Converted to Cropland	CO_2	57.4	0.1	98.8
1.B.2.c.2.iii	Flaring – Combined	CO_2	54.2	0.0	98.8
4.A.1	Forest Land – Forest Land Remaining Forest Land	CH_4	47.8	0.0	98.9
4.E.2	Settlements – Land Converted to Settlements	CO_2	47.5	0.0	98.9
1.A.2.f	Manufacturing Industries and Construction – Non-metallic Minerals Gaseous Fuels	CO_2	46.9	0.0	99.0
1.A.4.b	Other Sectors – Residential Biomass	CH_4	45.2	0.0	99.0

Note: Key categories are those that comprise 95 per cent of the total. Removals from the LULUCF sector are shown as negatives in this table. In line with the key category methodologies in the IPCC 2006 Guidelines, the absolute values for those removals are used for the calculations.

Table A1.3.1(b) Results of the key category level analysis for 99 per cent of the gross emissions and removals for New Zealand in 2020

IPCC Tier 1 category level assessment – gross emissions (excluding LULUCF): 2020					
CRF category code	IPCC Category	Gas	2020 estimate (kt CO_2-e)	Level assessment (%)	Cumulative total (%)
3.A.1	Option A – Dairy Cattle	CH_4	14,034.7	17.8	17.8
1.A.3.b	Transport – Road Transportation Liquid Fuels	CO_2	11,947.2	15.2	33.0
3.A.2	Other (please specify) – Sheep	CH_4	8,271.2	10.5	43.5
3.A.1	Option A – Non-Dairy Cattle	CH_4	5,980.9	7.6	51.1
3.D.1.3	Direct N_2O Emissions from Managed Soils – Urine and Dung Deposited by Grazing Animals	N_2O	3,890.0	4.9	56.0
1.A.1.a	Energy Industries – Public Electricity and Heat Production Gaseous Fuels	CO_2	2,697.3	3.4	59.4
5.A	Waste – Solid Waste Disposal	CH_4	2,637.7	3.3	62.8
1.A.1.a	Energy Industries – Public Electricity and Heat Production Solid Fuels	CO_2	1,809.3	2.3	65.1
1.A.2.e	Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco Solid Fuels	CO_2	1,702.0	2.2	67.2
2.C.1	Metal Industry – Iron and Steel Production	CO_2	1,578.6	2.0	69.2
3.D.1.1	Direct N_2O Emissions from Managed Soils – Inorganic N Fertilizers	N_2O	1,548.2	2.0	71.2
1.A.2.c	Manufacturing Industries and Construction – Chemicals Gaseous Fuels	CO_2	1,540.1	2.0	73.2
2.F.1	Product Uses as Substitutes for ODS – Refrigeration and Air conditioning	HFCs	1,391.6	1.8	74.9
3.B.1.1	Option A – Dairy Cattle	CH_4	1,387.1	1.8	76.7
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing Liquid Fuels	CO_2	1,362.6	1.7	78.4
1.A.4.b	Other Sectors – Residential Liquid Fuels	CO_2	1,313.1	1.7	80.1
1.A.2.e	Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco Gaseous Fuels	CO_2	1,086.7	1.4	81.5
3.D.2.1	Indirect N_2O Emissions from Managed Soils – Atmospheric Deposition	N_2O	925.2	1.2	82.6
1.A.4.a	Other Sectors – Commercial/Institutional Liquid Fuels	CO_2	707.9	0.9	83.5
1.A.3.a	Domestic Aviation – Jet Kerosene	CO_2	681.4	0.9	84.4

IPCC Tier 1 category level assessment – gross emissions (excluding LULUCF): 2020					
CRF category code	IPCC Category	Gas	2020 estimate (kt CO_2-e)	Level assessment (%)	Cumulative total (%)
3.D.1.6	Direct N_2O Emissions from Managed Soils – Cultivation of Organic Soils	N_2O	667.6	0.8	85.3
2.C.3	Metal Industry – Aluminium Production	CO_2	549.2	0.7	85.9
1.A.1.b	Energy Industries – Petroleum Refining Liquid Fuels	CO_2	543.8	0.7	86.6
3.H	Agriculture – Urea Application	CO_2	542.0	0.7	87.3
3.D.2.2	Indirect N_2O Emissions from Managed Soils – Nitrogen Leaching and Run-off	N_2O	516.9	0.7	88.0
3.A.4	Other Livestock – Deer	CH_4	497.6	0.6	88.6
1.B.2.d	Other (please specify) – Geothermal	CO_2	449.7	0.6	89.2
1.A.2.g.v	Other (please specify) – Construction	CO_2	446.9	0.6	89.8
1.A.4.a	Other Sectors – Commercial/Institutional Gaseous Fuels	CO_2	426.6	0.5	90.3
3.G	Agriculture – Liming	CO_2	409.5	0.5	90.8
1.A.4.b	Other Sectors – Residential Gaseous Fuels	CO_2	388.4	0.5	91.3
2.A.1	Mineral Industry – Cement Production	CO_2	379.2	0.5	91.8
1.A.2.g.iii	Other (please specify) – Mining (excluding fuels) and Quarrying Liquid Fuels	CO_2	365.4	0.5	92.3
1.A.2.d	Manufacturing Industries and Construction – Pulp, Paper and Print Gaseous Fuels	CO_2	306.7	0.4	92.6
1.A.3.d	Domestic Navigation – Residual Fuel Oil	CO_2	271.8	0.3	93.0
1.A.1.c	Energy Industries – Manufacture of Solid Fuels and Other Energy Industries Gaseous Fuels	CO_2	263.7	0.3	93.3
3.D.1.4	Direct N_2O Emissions from Managed Soils – Crop Residues	N_2O	258.6	0.3	93.7
5.D	Waste – Wastewater Treatment and Discharge	CH_4	256.9	0.3	94.0
1.B.2.c.1.ii	Venting – Gas	CO_2	256.6	0.3	94.3
1.A.2.e	Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco Liquid Fuels	CO_2	255.9	0.3	94.6
1.A.2.g.viii	Other (please specify) – Other (please specify) Liquid Fuels	CO_2	212.3	0.3	94.9
1.B.2.b.5	Natural Gas – Distribution	CH_4	192.2	0.2	95.1
1.A.2.f	Manufacturing Industries and Construction – Non-metallic Minerals Solid Fuels	CO_2	178.4	0.2	95.4
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing Solid Fuels	CO_2	171.8	0.2	95.6
1.A.1.b	Energy Industries – Petroleum Refining Gaseous Fuels	CO_2	148.2	0.2	95.8
1.B.2.b.2	Natural Gas – Production	CH_4	141.7	0.2	96.0
2.B.10	Chemical Industry – Other (please specify)	CO_2	134.2	0.2	96.1
5.D	Waste – Wastewater Treatment and Discharge	N_2O	120.4	0.2	96.3
1.A.2.a	Manufacturing Industries and Construction – Iron and Steel Gaseous Fuels	CO_2	119.5	0.2	96.4
1.B.2.d	Other (please specify) – Geothermal	CH_4	118.4	0.2	96.6
1.A.3.c	Transport – Railways Liquid Fuels	CO_2	112.9	0.1	96.7
3.B.2.5	N_2O and NMVOC Emissions – Indirect N_2O Emissions	N_2O	100.9	0.1	96.8
1.A.1.a	Energy Industries – Public Electricity and Heat Production Liquid Fuels	CO_2	99.2	0.1	97.0
2.B.8	Chemical Industry – Petrochemical and Carbon Black Production	CH_4	96.1	0.1	97.1

IPCC Tier 1 category level assessment – gross emissions (excluding LULUCF): 2020					
CRF category code	IPCC Category	Gas	2020 estimate (kt CO_2-e)	Level assessment (%)	Cumulative total (%)
3.B.1.2	CH_4 Emissions – Sheep	CH_4	91.9	0.1	97.2
2.A.2	Mineral Industry – Lime Production	CO_2	91.4	0.1	97.3
5.C	Waste – Incineration and Open Burning of Waste	CO_2	89.8	0.1	97.4
2.C.3	Metal Industry – Aluminium Production	PFCs	87.9	0.1	97.6
3.B.1.1	Option A – Non-Dairy Cattle	CH_4	82.9	0.1	97.7
2.F.4	Product Uses as Substitutes for ODS – Aerosols	HFCs	80.1	0.1	97.8
5.C	Waste – Incineration and Open Burning of Waste	CH_4	77.4	0.1	97.9
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing Gaseous Fuels	CO_2	76.5	0.1	98.0
3.D.1.2	Direct N_2O Emissions from Managed Soils – Organic N Fertilizers	N_2O	76.2	0.1	98.1
2.G.3	Other Product Manufacture and Use – N_2O from Product Uses	N_2O	73.9	0.1	98.1
1.A.2.d	Manufacturing Industries and Construction – Pulp, Paper and Print Liquid Fuels	CO_2	68.5	0.1	98.2
2.A.4	Mineral Industry – Other Process Uses of Carbonates	CO_2	66.8	0.1	98.3
1.B.1.a.2	Coal Mining and Handling – Surface Mines	CH_4	61.4	0.1	98.4
1.A.3.b	Transport – Road Transportation Liquid Fuels	N_2O	61.1	0.1	98.5
1.A.2.f	Manufacturing Industries and Construction – Non-metallic Minerals Liquid Fuels	CO_2	60.0	0.1	98.6
1.A.4.a	Other Sectors – Commercial/Institutional Solid Fuels	CO_2	57.7	0.1	98.6
1.B.2.c.2.iii	Flaring – Combined	CO_2	54.2	0.1	98.7
1.A.2.f	Manufacturing Industries and Construction – Non-metallic Minerals Gaseous Fuels	CO_2	46.9	0.1	98.8
1.A.4.b	Other Sectors – Residential Biomass	CH_4	45.2	0.1	98.8
2.D	Industrial Processes and Product Use – Non-energy Products from Fuels and Solvent Use	CO_2	44.1	0.1	98.9
1.A.3.e	Transport – Other Transportation (please specify) Gaseous Fuels	CO_2	42.7	0.1	98.9
5.B	Waste – Biological Treatment of Solid Waste	CH_4	39.9	0.1	99.0
1.A.2.g.viii	Other (please specify) – Other (please specify) Solid Fuels	CO_2	35.3	0.0	99.0

Note: Key categories are those that comprise 95 per cent of the total.

Table A1.3.2(a) Results of the level analysis for 99 per cent of the net emissions and removals for New Zealand in 1990 included for reference only

IPCC Tier 1 category level assessment – including LULUCF (net emissions): 1990					
CRF category code	IPCC category	Gas	1990 estimate (kt CO_2-e)	Level assessment (%)	Cumulative total (%)
4.A.2	Forest Land – Land Converted to Forest Land	CO_2	–18,334.3	20.5	20.5
3.A.2	Other (please specify) – Sheep	CH_4	14,557.9	16.3	36.7
1.A.3.b	Transport – Road Transportation Liquid Fuels	CO_2	6,519.0	7.3	44.0
3.A.1	Option A – Dairy Cattle	CH_4	6,147.3	6.9	50.9
3.A.1	Option A – Non-Dairy Cattle	CH_4	5,950.0	6.6	57.5
5.A	Waste – Solid Waste Disposal	CH_4	3,318.2	3.7	61.2

IPCC Tier 1 category level assessment – including LULUCF (net emissions): 1990					
CRF category code	IPCC category	Gas	1990 estimate (kt CO_2-e)	Level assessment (%)	Cumulative total (%)
3.D.1.3	Direct N_2O Emissions from Managed Soils – Urine and Dung Deposited by Grazing Animals	N_2O	3,068.6	3.4	64.6
1.A.1.a	Energy Industries – Public Electricity and Heat Production Gaseous Fuels	CO_2	2,999.6	3.3	68.0
4.G	Land Use, Land-Use Change and Forestry – Harvested Wood Products	CO_2	–2,481.2	2.8	70.8
4.A.1	Forest Land – Forest Land Remaining Forest Land	CO_2	–1,965.5	2.2	73.0
1.A.1.c	Energy Industries – Manufacture of Solid Fuels and Other Energy Industries Gaseous Fuels	CO_2	1,715.3	1.9	74.9
2.C.1	Metal Industry – Iron and Steel Production	CO_2	1,306.7	1.5	76.3
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing Liquid Fuels	CO_2	1,071.4	1.2	77.5
1.A.2.e	Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco Solid Fuels	CO_2	938.6	1.0	78.6
2.C.3	Metal Industry – Aluminium Production	PFCs	909.9	1.0	79.6
1.A.3.a	Domestic Aviation – Jet Kerosene	CO_2	892.6	1.0	80.6
1.A.4.b	Other Sectors – Residential Liquid Fuels	CO_2	814.5	0.9	81.5
1.A.1.b	Energy Industries – Petroleum Refining Liquid Fuels	CO_2	778.9	0.9	82.4
3.D.2.1	Indirect N_2O Emissions from Managed Soils – Atmospheric Deposition	N_2O	735.1	0.8	83.2
1.A.2.g.viii	Other (please specify) – Other (please specify) Solid Fuels	CO_2	731.1	0.8	84.0
3.D.1.6	Direct N_2O Emissions from Managed Soils – Cultivation of Organic Soils	N_2O	658.7	0.7	84.7
1.A.2.c	Manufacturing Industries and Construction – Chemicals Gaseous Fuels	CO_2	524.8	0.6	85.3
1.A.4.a	Other Sectors – Commercial/Institutional Liquid Fuels	CO_2	500.7	0.6	85.9
1.A.1.a	Energy Industries – Public Electricity and Heat Production Solid Fuels	CO_2	474.8	0.5	86.4
2.C.3	Metal Industry – Aluminium Production	CO_2	449.0	0.5	86.9
2.A.1	Mineral Industry – Cement Production	CO_2	448.7	0.5	87.4
3.A.4	Other livestock – Deer	CH_4	445.5	0.5	87.9
1.A.2.e	Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco Gaseous Fuels	CO_2	443.4	0.5	88.4
3.B.1.1	Option A – Dairy Cattle	CH_4	416.6	0.5	88.9
3.D.2.2	Indirect N_2O Emissions from Managed Soils – Nitrogen Leaching and Run-off	N_2O	396.5	0.4	89.3
4.C.2	Grassland – Land Converted to Grassland	CO_2	389.8	0.4	89.7
1.A.2.f	Manufacturing Industries and Construction – Non-metallic Minerals Solid Fuels	CO_2	382.9	0.4	90.2
4.B.1	Cropland – Cropland Remaining Cropland	CO_2	351.1	0.4	90.6
1.A.2.d	Manufacturing Industries and Construction – Pulp, Paper and Print Gaseous Fuels	CO_2	347.6	0.4	91.0
1.A.4.b	Other Sectors – Residential Solid Fuels	CO_2	344.9	0.4	91.3
3.G	Agriculture – Liming	CO_2	296.5	0.3	91.7
1.B.1.a.1	Coal Mining and Handling – Underground Mines	CH_4	289.6	0.3	92.0
1.A.2.e	Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco Liquid Fuels	CO_2	281.1	0.3	92.3
1.B.2.b.5	Natural Gas – Distribution	CH_4	277.5	0.3	92.6
1.A.2.g.v	Other (please specify) – Construction	CO_2	245.0	0.3	92.9

IPCC Tier 1 category level assessment – including LULUCF (net emissions): 1990					
CRF category code	IPCC category	Gas	1990 estimate (kt CO_2-e)	Level assessment (%)	Cumulative total (%)
1.A.4.a	Other Sectors – Commercial/Institutional Gaseous Fuels	CO_2	235.2	0.3	93.2
1.A.3.d	Domestic Navigation – Residual Fuel Oil	CO_2	232.9	0.3	93.4
3.D.1.1	Direct N_2O Emissions from Managed Soils – Inorganic N Fertilizers	N_2O	230.3	0.3	93.7
1.B.2.d	Other (please specify) – Geothermal	CO_2	228.6	0.3	93.9
5.D	Waste – Wastewater Treatment and Discharge	CH_4	222.5	0.2	94.2
4.C.1	Grassland – Grassland Remaining Grassland	CO_2	220.0	0.2	94.4
3.A.4	Other Livestock – Goats	CH_4	196.6	0.2	94.6
1.A.4.b	Other Sectors – Residential Gaseous Fuels	CO_2	184.9	0.2	94.8
3.D.1.4	Direct N_2O Emissions from Managed Soils – Crop Residues	N_2O	175.5	0.2	95.0
5.C	Waste – Incineration and Open Burning of Waste	CO_2	158.9	0.2	95.2
2.B.10	Chemical Industry – Other (please specify)	CO_2	152.3	0.2	95.4
3.B.1.2	CH_4 Emissions – Sheep	CH_4	148.8	0.2	95.6
1.B.2.b.2	Natural Gas – Production	CH_4	143.5	0.2	95.7
1.A.4.a	Other Sectors – Commercial/Institutional Solid Fuels	CO_2	142.2	0.2	95.9
1.A.3.b	Transport – Road Transportation Gaseous Fuels	CO_2	140.3	0.2	96.0
5.C	Waste – Incineration and Open Burning of Waste	CH_4	127.4	0.1	96.2
4.A.2	Forest Land – Land Converted to Forest Land	N_2O	124.2	0.1	96.3
4.B.2	Cropland – Land Converted to Cropland	CO_2	117.5	0.1	96.4
1.A.2.a	Manufacturing Industries and Construction – Iron and Steel Gaseous Fuels	CO_2	116.2	0.1	96.6
1.B.2.c.2.iii	Flaring – Combined	CO_2	114.1	0.1	96.7
1.A.2.d	Manufacturing Industries and Construction – Pulp, Paper and Print Solid Fuels	CO_2	109.5	0.1	96.8
1.B.2.c.1.ii	Venting – Gas	CO_2	109.3	0.1	96.9
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing Gaseous Fuels	CO_2	105.8	0.1	97.1
2.G.3	Other Product Manufacture and Use – N_2O from Product Uses	N_2O	102.4	0.1	97.2
1.A.2.g.iii	Other (please specify) – Mining (excluding fuels) and Quarrying Liquid Fuels	CO_2	94.1	0.1	97.3
1.B.2.c.1.iii	Venting – Combined	CH_4	93.8	0.1	97.4
1.A.3.b	Transport – Road Transportation Liquid Fuels	N_2O	89.3	0.1	97.5
2.A.2	Mineral Industry – Lime Production	CO_2	82.6	0.1	97.6
3.B.1.1	Option A – Non-Dairy Cattle	CH_4	82.0	0.1	97.7
5.D	Waste – Wastewater Treatment and Discharge	N_2O	82.0	0.1	97.8
1.A.3.c	Transport – Railways Liquid Fuels	CO_2	78.4	0.1	97.8
4.A	Forest Land – Emissions and removals from drainage and rewetting and other management of organic and mineral soils	N_2O	78.0	0.1	97.9
1.A.3.b	Transport – Road Transportation Liquid Fuels	CH_4	72.9	0.1	98.0
4.E.1	Settlements – Settlements Remaining Settlements	CO_2	67.2	0.1	98.1
1.B.2.c.2.iii	Flaring – Combined	CH_4	64.6	0.1	98.2
1.A.2.f	Manufacturing Industries and Construction – Non-metallic Minerals Gaseous Fuels	CO_2	64.1	0.1	98.2
1.A.2.g.vi	Other (please specify) – Textile and Leather Gaseous Fuels	CO_2	58.9	0.1	98.3
3.B.1.3	CH_4 Emissions – Swine	CH_4	58.6	0.1	98.4

IPCC Tier 1 category level assessment – including LULUCF (net emissions): 1990					
CRF category code	IPCC category	Gas	1990 estimate (kt CO_2-e)	Level assessment (%)	Cumulative total (%)
1.B.2.d	Other (please specify) – Geothermal	CH_4	54.8	0.1	98.4
1.A.2.g.viii	Other (please specify) – Other (please specify) Liquid Fuels	CO_2	52.3	0.1	98.5
1.A.2.d	Manufacturing Industries and Construction – Pulp, Paper and Print Liquid Fuels	CO_2	50.1	0.1	98.5
1.A.4.b	Other Sectors – Residential Biomass	CH_4	48.4	0.1	98.6
4.C.1	Grassland – Grassland Remaining Grassland	CH_4	47.7	0.1	98.6
1.A.3.a	Domestic Aviation – Aviation Gasoline	CO_2	47.7	0.1	98.7
1.A.2.f	Manufacturing Industries and Construction – Non-metallic Minerals Liquid Fuels	CO_2	46.0	0.1	98.8
3.A.4	Other livestock – Horses	CH_4	42.3	0.0	98.8
1.A.2.g.i	Other (please specify) – Manufacturing of machinery Gaseous Fuels	CO_2	41.8	0.0	98.8
–	Land Use, Land-Use Change and Forestry – Indirect N_2O Emissions from Managed Soils	N_2O	40.8	0.0	98.9
3.H	Agriculture – Urea Application	CO_2	39.2	0.0	98.9
1.B.1.a.2	Coal Mining and Handling – Surface Mines	CH_4	38.5	0.0	99.0
3.D.1.2	Direct N_2O Emissions from Managed Soils – Organic N Fertilizers	N_2O	36.3	0.0	99.0

Note: Removals from the LULUCF sector are shown as negatives in this table. In line with the key category methodologies in the IPCC 2006 Guidelines, the absolute values for those removals are used for the calculations.

Table A1.3.2(b) Results of the level analysis for 99 per cent of the gross emissions for New Zealand in 1990 included for reference only

IPCC Tier 1 category level assessment – gross emissions (excluding LULUCF): 1990					
CRF category code	IPCC category	Gas	1990 estimate (kt CO_2-e)	Level assessment (%)	Cumulative total (%)
3.A.2	Other (please specify) – Sheep	CH_4	14,557.9	22.3	22.3
1.A.3.b	Transport – Road Transportation Liquid Fuels	CO_2	6,519.0	10.0	32.3
3.A.1	Option A – Dairy Cattle	CH_4	6,147.3	9.4	41.8
3.A.1	Option A – Non-Dairy Cattle	CH_4	5,950.0	9.1	50.9
5.A	Waste – Solid Waste Disposal	CH_4	3,318.2	5.1	56.0
3.D.1.3	Direct N_2O Emissions from Managed Soils – Urine and Dung Deposited by Grazing Animals	N_2O	3,068.6	4.7	60.7
1.A.1.a	Energy Industries – Public Electricity and Heat Production Gaseous Fuels	CO_2	2,999.6	4.6	65.3
1.A.1.c	Energy Industries – Manufacture of Solid Fuels and Other Energy Industries Gaseous Fuels	CO_2	1,715.3	2.6	67.9
2.C.1	Metal Industry – Iron and Steel Production	CO_2	1,306.7	2.0	69.9
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing Liquid Fuels	CO_2	1,071.4	1.6	71.6
1.A.2.e	Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco Solid Fuels	CO_2	938.6	1.4	73.0
2.C.3	Metal Industry – Aluminium Production	PFCs	909.9	1.4	74.4
1.A.3.a	Domestic Aviation – Jet Kerosene	CO_2	892.6	1.4	75.8
1.A.4.b	Other Sectors – Residential Liquid Fuels	CO_2	814.5	1.2	77.0
1.A.1.b	Energy Industries – Petroleum Refining Liquid Fuels	CO_2	778.9	1.2	78.2
3.D.2.1	Indirect N_2O Emissions from Managed Soils – Atmospheric Deposition	N_2O	735.1	1.1	79.3

IPCC Tier 1 category level assessment – gross emissions (excluding LULUCF): 1990					
CRF category code	IPCC category	Gas	1990 estimate (kt CO_2-e)	Level assessment (%)	Cumulative total (%)
1.A.2.g.viii	Other (please specify) – Other (please specify) Solid Fuels	CO_2	731.1	1.1	80.5
3.D.1.6	Direct N_2O Emissions from Managed Soils – Cultivation of Organic Soils	N_2O	658.7	1.0	81.5
1.A.2.c	Manufacturing Industries and Construction – Chemicals Gaseous Fuels	CO_2	524.8	0.8	82.3
1.A.4.a	Other Sectors – Commercial/Institutional Liquid Fuels	CO_2	500.7	0.8	83.0
1.A.1.a	Energy Industries – Public Electricity and Heat Production Solid Fuels	CO_2	474.8	0.7	83.8
2.C.3	Metal Industry – Aluminium Production	CO_2	449.0	0.7	84.5
2.A.1	Mineral Industry – Cement Production	CO_2	448.7	0.7	85.1
3.A.4	Other livestock – Deer	CH_4	445.5	0.7	85.8
1.A.2.e	Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco Gaseous Fuels	CO_2	443.4	0.7	86.5
3.B.1.1	Option A – Dairy Cattle	CH_4	416.6	0.6	87.1
3.D.2.2	Indirect N_2O Emissions from Managed Soils – Nitrogen Leaching and Run-off	N_2O	396.5	0.6	87.8
1.A.2.f	Manufacturing Industries and Construction – Non-metallic Minerals Solid Fuels	CO_2	382.9	0.6	88.3
1.A.2.d	Manufacturing Industries and Construction – Pulp, Paper and Print Gaseous Fuels	CO_2	347.6	0.5	88.9
1.A.4.b	Other Sectors – Residential Solid Fuels	CO_2	344.9	0.5	89.4
3.G	Agriculture – Liming	CO_2	296.5	0.5	89.9
1.B.1.a.1	Coal Mining and Handling – Underground Mines	CH_4	289.6	0.4	90.3
1.A.2.e	Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco Liquid Fuels	CO_2	281.1	0.4	90.7
1.B.2.b.5	Natural Gas – Distribution	CH_4	277.5	0.4	91.2
1.A.2.g.v	Other (please specify) – Construction	CO_2	245.0	0.4	91.5
1.A.4.a	Other Sectors – Commercial/Institutional Gaseous Fuels	CO_2	235.2	0.4	91.9
1.A.3.d	Domestic Navigation – Residual Fuel Oil	CO_2	232.9	0.4	92.3
3.D.1.1	Direct N_2O Emissions from Managed Soils – Inorganic N Fertilizers	N_2O	230.3	0.4	92.6
1.B.2.d	Other (please specify) – Geothermal	CO_2	228.6	0.4	93.0
5.D	Waste – Wastewater Treatment and Discharge	CH_4	222.5	0.3	93.3
3.A.4	Other livestock – Goats	CH_4	196.6	0.3	93.6
1.A.4.b	Other Sectors – Residential Gaseous Fuels	CO_2	184.9	0.3	93.9
3.D.1.4	Direct N_2O Emissions from Managed Soils – Crop Residues	N_2O	175.5	0.3	94.2
5.C	Waste – Incineration and Open Burning of Waste	CO_2	158.9	0.2	94.4
2.B.10	Chemical Industry – Other (please specify)	CO_2	152.3	0.2	94.6
3.B.1.2	CH_4 Emissions – Sheep	CH_4	148.8	0.2	94.9
1.B.2.b.2	Natural Gas – Production	CH_4	143.5	0.2	95.1
1.A.4.a	Other Sectors – Commercial/Institutional Solid Fuels	CO_2	142.2	0.2	95.3
1.A.3.b	Transport – Road Transportation Gaseous Fuels	CO_2	140.3	0.2	95.5
5.C	Waste – Incineration and Open Burning of Waste	CH_4	127.4	0.2	95.7
1.A.2.a	Manufacturing Industries and Construction – Iron and Steel Gaseous Fuels	CO_2	116.2	0.2	95.9

IPCC Tier 1 category level assessment – gross emissions (excluding LULUCF): 1990					
CRF category code	IPCC category	Gas	1990 estimate (kt CO_2-e)	Level assessment (%)	Cumulative total (%)
1.B.2.c.2.iii	Flaring – Combined	CO_2	114.1	0.2	96.1
1.A.2.d	Manufacturing Industries and Construction – Pulp, Paper and Print Solid Fuels	CO_2	109.5	0.2	96.2
1.B.2.c.1.ii	Venting – Gas	CO_2	109.3	0.2	96.4
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing Gaseous Fuels	CO_2	105.8	0.2	96.6
2.G.3	Other Product Manufacture and Use – N_2O from Product Uses	N_2O	102.4	0.2	96.7
1.A.2.g.iii	Other (please specify) – Mining (excluding fuels) and Quarrying Liquid Fuels	CO_2	94.1	0.1	96.9
1.B.2.c.1.iii	Venting – Combined	CH_4	93.8	0.1	97.0
1.A.3.b	Transport – Road Transportation Liquid Fuels	N_2O	89.3	0.1	97.1
2.A.2	Mineral Industry – Lime Production	CO_2	82.6	0.1	97.3
3.B.1.1	Option A – Non-Dairy Cattle	CH_4	82.0	0.1	97.4
5.D	Waste – Wastewater Treatment and Discharge	N_2O	82.0	0.1	97.5
1.A.3.c	Transport – Railways Liquid Fuels	CO_2	78.4	0.1	97.6
1.A.3.b	Transport – Road Transportation Liquid Fuels	CH_4	72.9	0.1	97.8
1.B.2.c.2.iii	Flaring – Combined	CH_4	64.6	0.1	97.9
1.A.2.f	Manufacturing Industries and Construction – Non-metallic Minerals Gaseous Fuels	CO_2	64.1	0.1	97.9
1.A.2.g.vi	Other (please specify) – Textile and leather Gaseous Fuels	CO_2	58.9	0.1	98.0
3.B.1.3	CH_4 Emissions – Swine	CH_4	58.6	0.1	98.1
1.B.2.d	Other (please specify) – Geothermal	CH_4	54.8	0.1	98.2
1.A.2.g.viii	Other (please specify) – Other (please specify) Liquid Fuels	CO_2	52.3	0.1	98.3
1.A.2.d	Manufacturing Industries and Construction – Pulp, Paper and Print Liquid Fuels	CO_2	50.1	0.1	98.4
1.A.4.b	Other Sectors – Residential Biomass	CH_4	48.4	0.1	98.4
1.A.3.a	Domestic Aviation – Aviation Gasoline	CO_2	47.7	0.1	98.5
1.A.2.f	Manufacturing Industries and Construction – Non-metallic Minerals Liquid Fuels	CO_2	46.0	0.1	98.6
3.A.4	Other Livestock – Horses	CH_4	42.3	0.1	98.7
1.A.2.g.i	Other (please specify) – Manufacturing of Machinery Gaseous Fuels	CO_2	41.8	0.1	98.7
3.H	Agriculture – Urea Application	CO_2	39.2	0.1	98.8
1.B.1.a.2	Coal Mining and Handling – Surface Mines	CH_4	38.5	0.1	98.8
3.D.1.2	Direct N_2O Emissions from Managed Soils – Organic N Fertilizers	N_2O	36.3	0.1	98.9
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing Solid Fuels	CO_2	35.1	0.1	98.9
3.B.2.5	N_2O and NMVOC Emissions – Indirect N_2O Emissions	N_2O	34.7	0.1	99.0
1.A.2.d	Manufacturing Industries and Construction – Pulp, Paper and Print Biomass	N_2O	33.3	0.1	99.1

Table A1.3.3(a) Results of the key category trend analysis for 99 per cent of the net emissions and removals for New Zealand in 1990–2020

IPCC Tier 1 category trend assessment – including LULUCF (net emissions)							
CRF category code	IPCC category	Gas	1990 estimate (kt CO_2-e)	2020 estimate (kt CO_2-e)	Trend assessment	Contribution to trend (%)	Cumulative total (%)
4.A.1	Forest Land – Forest Land Remaining Forest Land	CO_2	−1,965.5	−15,345.3	0.155	19.0	19.0
3.A.2	Other (please specify) – Sheep	CH_4	14,557.9	8,271.2	0.113	13.8	32.9
4.A.2	Forest Land – Land Converted to Forest Land	CO_2	−18,334.3	−4,638.0	0.099	12.2	45.1
3.A.1	Option A – Dairy Cattle	CH_4	6,147.3	14,034.7	0.070	8.6	53.7
4.G	Land Use, Land-Use Change and Forestry – Harvested Wood Products	CO_2	−2,481.2	−6,834.6	0.056	6.9	60.5
1.A.3.b	Transport – Road Transportation Liquid Fuels	CO_2	6,519.0	11,947.2	0.042	5.1	65.6
1.A.1.c	Energy Industries – Manufacture of Solid Fuels and Other Energy Industries Gaseous Fuels	CO_2	1,715.3	263.7	0.021	2.6	68.2
5.A	Waste – Solid Waste Disposal	CH_4	3,318.2	2,637.7	0.017	2.1	70.3
3.A.1	Option A – Non-Dairy Cattle	CH_4	5,950.0	5,980.9	0.017	2.1	72.4
2.F.1	Product Uses as Substitutes for ODS – Refrigeration and Air Conditioning	HFCs	0.0	1,391.6	0.016	1.9	74.3
3.D.1.1	Direct N_2O Emissions from Managed Soils – Inorganic N Fertilizers	N_2O	230.3	1,548.2	0.014	1.7	76.0
1.A.1.a	Energy Industries – Public Electricity and Heat Production Solid Fuels	CO_2	474.8	1,809.3	0.014	1.7	77.7
1.A.1.a	Energy Industries – Public Electricity and Heat Production Gaseous Fuels	CO_2	2,999.6	2,697.3	0.012	1.5	79.2
2.C.3	Metal Industry – Aluminium Production	PFCs	909.9	87.9	0.012	1.5	80.6
4.C.1	Grassland – Grassland Remaining Grassland	CO_2	220.0	1,225.5	0.011	1.3	81.9
1.A.2.g.viii	Other (please specify) – Other (please specify) Solid Fuels	CO_2	731.1	35.3	0.010	1.2	83.2
1.A.2.c	Manufacturing Industries and Construction – Chemicals Gaseous Fuels	CO_2	524.8	1,540.1	0.010	1.2	84.4
3.B.1.1	Option A – Dairy Cattle	CH_4	416.6	1,387.1	0.010	1.2	85.5
4.C.2	Grassland – Land Converted to Grassland	CO_2	389.8	1,299.0	0.009	1.1	86.7
1.A.2.e	Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco Gaseous Fuels	CO_2	443.4	1,086.7	0.006	0.7	87.4
1.A.2.e	Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco Solid Fuels	CO_2	938.6	1,702.0	0.006	0.7	88.1
3.H	Agriculture – Urea Application	CO_2	39.2	542.0	0.005	0.7	88.8
1.A.3.a	Domestic Aviation – Jet Kerosene	CO_2	892.6	681.4	0.005	0.6	89.4
1.A.1.b	Energy Industries – Petroleum Refining Liquid Fuels	CO_2	778.9	543.8	0.005	0.6	90.0

IPCC Tier 1 category trend assessment – including LULUCF (net emissions)							
CRF category code	IPCC category	Gas	1990 estimate (kt CO_2-e)	2020 estimate (kt CO_2-e)	Trend assessment	Contribution to trend (%)	Cumulative total (%)
1.A.4.b	Other Sectors – Residential Solid Fuels	CO_2	344.9	28.4	0.005	0.6	90.5
1.B.1.a.1	Coal Mining and Handling – Underground Mines	CH_4	289.6	0.0	0.004	0.5	91.0
1.A.2.f	Manufacturing Industries and Construction – Non-metallic Minerals Solid Fuels	CO_2	382.9	178.4	0.003	0.4	91.4
1.A.4.b	Other Sectors – Residential Liquid Fuels	CO_2	814.5	1,313.1	0.003	0.4	91.8
1.A.2.g.iii	Other (please specify) – Mining (excluding fuels) and Quarrying Liquid Fuels	CO_2	94.1	365.4	0.003	0.3	92.2
3.A.4	Other Livestock – Goats	CH_4	196.6	21.6	0.003	0.3	92.5
2.A.1	Mineral Industry – Cement Production	CO_2	448.7	379.2	0.002	0.3	92.7
1.A.3.b	Transport – Road Transportation Gaseous Fuels	CO_2	140.3	0.0	0.002	0.2	93.0
3.D.1.6	Direct N_2O Emissions from Managed Soils – Cultivation of Organic Soils	N_2O	658.7	667.6	0.002	0.2	93.2
1.B.2.d	Other (please specify) – Geothermal	CO_2	228.6	449.7	0.002	0.2	93.4
1.B.2.b.5	Natural Gas – Distribution	CH_4	277.5	192.2	0.002	0.2	93.6
1.A.4.b	Other Sectors – Residential Gaseous Fuels	CO_2	184.9	388.4	0.002	0.2	93.9
1.A.1.b	Energy Industries – Petroleum Refining Gaseous Fuels	CO_2	0.0	148.2	0.002	0.2	94.1
1.A.2.g.viii	Other (please specify) – Other (please specify) Liquid Fuels	CO_2	52.3	212.3	0.002	0.2	94.3
1.A.2.g.v	Other (please specify) – Construction	CO_2	245.0	446.9	0.002	0.2	94.4
1.A.2.d	Manufacturing Industries and Construction – Pulp, Paper and Print Gaseous Fuels	CO_2	347.6	306.7	0.001	0.2	94.6
1.A.4.a	Other Sectors – Commercial/ Institutional Gaseous Fuels	CO_2	235.2	426.6	0.001	0.2	94.8
1.A.4.c	Other Sectors – Agriculture/ Forestry/Fishing Solid Fuels	CO_2	35.1	171.8	0.001	0.2	95.0
4.B.1	Cropland – Cropland Remaining Cropland	CO_2	351.1	318.2	0.001	0.2	95.2
1.A.4.a	Other Sectors – Commercial/ Institutional Solid Fuels	CO_2	142.2	57.7	0.001	0.2	95.3
1.B.2.c.1.ii	Venting – Gas	CO_2	109.3	256.6	0.001	0.2	95.5
1.A.2.d	Manufacturing Industries and Construction – Pulp, Paper and Print Solid Fuels	CO_2	109.5	23.1	0.001	0.2	95.6
5.C	Waste – Incineration and Open Burning of Waste	CO_2	158.9	89.8	0.001	0.2	95.8
1.A.2.e	Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco Liquid Fuels	CO_2	281.1	255.9	0.001	0.1	95.9
4.F.2	Other Land – Land Converted to Other Land	CO_2	13.5	114.3	0.001	0.1	96.1
3.B.1.2	CH_4 Emissions – Sheep	CH_4	148.8	91.9	0.001	0.1	96.2

IPCC Tier 1 category trend assessment – including LULUCF (net emissions)							
CRF category code	IPCC category	Gas	1990 estimate (kt CO_2-e)	2020 estimate (kt CO_2-e)	Trend assessment	Contribution to trend (%)	Cumulative total (%)
4.A.2	Forest Land – Land Converted to Forest Land	N_2O	124.2	64.5	0.001	0.1	96.3
4.B.2	Cropland – Land Converted to Cropland	CO_2	117.5	57.4	0.001	0.1	96.4
1.B.2.c.2.iii	Flaring – Combined	CO_2	114.1	54.2	0.001	0.1	96.6
1.A.1.a	Energy Industries – Public Electricity and Heat Production Liquid Fuels	CO_2	10.6	99.2	0.001	0.1	96.7
1.B.2.c.1.iii	Venting – Combined	CH_4	93.8	32.6	0.001	0.1	96.8
5.C	Waste – Incineration and Open Burning of Waste	CH_4	127.4	77.4	0.001	0.1	96.9
2.F.4	Product Uses as Substitutes for ODS – Aerosols	HFCs	0.0	80.1	0.001	0.1	97.0
1.A.3.b	Transport – Road Transportation Liquid Fuels	CH_4	72.9	14.4	0.001	0.1	97.1
1.A.4.a	Other Sectors – Commercial/ Institutional Liquid Fuels	CO_2	500.7	707.9	0.001	0.1	97.2
1.B.2.c.2.iii	Flaring – Combined	CH_4	64.6	10.9	0.001	0.1	97.3
2.C.1	Metal Industry – Iron and Steel Production	CO_2	1,306.7	1,578.6	0.001	0.1	97.4
3.A.4	Other livestock – Deer	CH_4	445.5	497.6	0.001	0.1	97.5
2.B.8	Chemical Industry – Petrochemical and Carbon Black Production	CH_4	27.6	96.1	0.001	0.1	97.6
2.B.10	Chemical Industry – Other (please specify)	CO_2	152.3	134.2	0.001	0.1	97.7
3.B.2.5	N_2O and NMVOC Emissions – Indirect N_2O Emissions	N_2O	34.7	100.9	0.001	0.1	97.8
1.A.4.c	Other Sectors – Agriculture/ Forestry/Fishing Gaseous Fuels	CO_2	105.8	76.5	0.001	0.1	97.8
2.G.3	Other Product Manufacture and Use – N_2O from Product Uses	N_2O	102.4	73.9	0.001	0.1	97.9
1.A.2.g.vi	Other (please specify) – Textile and Leather Gaseous Fuels	CO_2	58.9	22.1	0.001	0.1	98.0
1.A.3.b	Transport – Road Transportation Liquid Fuels	N_2O	89.3	61.1	0.001	0.1	98.1
1.B.2.d	Other (please specify) – Geothermal	CH_4	54.8	118.4	0.001	0.1	98.1
4.C.1	Grassland – Grassland Remaining Grassland	CH_4	47.7	17.0	0.000	0.1	98.2
1.B.2.b.2	Natural Gas – Production	CH_4	143.5	141.7	0.000	0.1	98.2
3.B.1.3	CH_4 Emissions – Swine	CH_4	58.6	34.8	0.000	0.1	98.3
1.A.2.g.i	Other (please specify) – Manufacturing of Machinery Gaseous Fuels	CO_2	41.8	14.6	0.000	0.1	98.3
1.A.3.a	Domestic Aviation – Aviation Gasoline	CO_2	47.7	22.4	0.000	0.1	98.4
3.D.1.4	Direct N_2O Emissions from Managed Soils – Crop Residues	N_2O	175.5	258.6	0.000	0.1	98.4
4.E.2	Settlements – Land Converted to Settlements	CO_2	8.3	47.5	0.000	0.1	98.5

IPCC Tier 1 category trend assessment – including LULUCF (net emissions)							
CRF category code	IPCC category	Gas	1990 estimate (kt CO_2-e)	2020 estimate (kt CO_2-e)	Trend assessment	Contribution to trend (%)	Cumulative total (%)
5.B	Waste – Biological Treatment of Solid Waste	CH_4	2.7	39.9	0.000	0.0	98.5
3.A.4	Other Livestock – Horses	CH_4	42.3	17.4	0.000	0.0	98.6
1.A.3.e	Transport – Other Transportation (please specify) Gaseous Fuels	CO_2	5.5	42.7	0.000	0.0	98.6
3.G	Agriculture – Liming	CO_2	296.5	409.5	0.000	0.0	98.7
1.A.2.f	Manufacturing Industries and Construction – Non-metallic Minerals Gaseous Fuels	CO_2	64.1	46.9	0.000	0.0	98.7
–	Land Use, Land-Use Change and Forestry – Indirect N_2O Emissions from Managed Soils	N_2O	40.8	17.7	0.000	0.0	98.8
1.A.4.b	Other Sectors – Residential Solid Fuels	CH_4	27.3	2.2	0.000	0.0	98.8
4.C.2	Grassland – Land Converted to Grassland	N_2O	28.6	5.0	0.000	0.0	98.9
3.D.1.2	Direct N_2O Emissions from Managed Soils – Organic N Fertilizers	N_2O	36.3	76.2	0.000	0.0	98.9
2.A.4	Mineral Industry – Other Process Uses of Carbonates	CO_2	30.5	66.8	0.000	0.0	98.9
1.A.2.a	Manufacturing Industries and Construction – Iron and Steel Gaseous Fuels	CO_2	116.2	119.5	0.000	0.0	99.0
4.C.1	Grassland – Grassland Remaining Grassland	N_2O	35.4	18.2	0.000	0.0	99.0

Note: Key categories are those that comprise 95 per cent of the total. Removals from the LULUCF sector are shown as negatives in this table. In line with the key category methodologies in the IPCC 2006 Guidelines, the absolute values for those removals are used for the calculations.

Table A1.3.3(b) Results of the key category trend analysis for 99 per cent of the gross emissions for New Zealand in 1990–2020

IPCC Tier 1 category trend assessment – gross emissions (excluding LULUCF)							
CRF Category code	IPCC Category	Gas	1990 estimate (kt CO_2-e)	2020 estimate (kt CO_2-e)	Trend assessment	Contribution to trend (%)	Cumulative total (%)
3.A.2	Other (please specify) – Sheep	CH_4	14,557.9	8,271.2	0.143	22.2	22.2
3.A.1	Option A – Dairy Cattle	CH_4	6,147.3	14,034.7	0.101	15.8	38.0
1.A.3.b	Transport – Road Transportation Liquid Fuels	CO_2	6,519.0	11,947.2	0.062	9.7	47.7
1.A.1.c	Energy Industries – Manufacture of Solid Fuels and Other Energy Industries Gaseous Fuels	CO_2	1,715.3	263.7	0.028	4.3	52.0
2.F.1	Product Uses as Substitutes for ODS – Refrigeration and Air Conditioning	HFCs	0.0	1,391.6	0.021	3.3	55.3
5.A	Waste – Solid Waste Disposal	CH_4	3,318.2	2,637.7	0.021	3.3	58.6
3.D.1.1	Direct N_2O Emissions from Managed Soils – Inorganic N Fertilizers	N_2O	230.3	1,548.2	0.019	3.0	61.6
1.A.1.a	Energy Industries – Public Electricity and Heat Production Solid Fuels	CO_2	474.8	1,809.3	0.019	2.9	64.6
3.A.1	Option A – Non-Dairy Cattle	CH_4	5,950.0	5,980.9	0.019	2.9	67.5

IPCC Tier 1 category trend assessment – gross emissions (excluding LULUCF)							
CRF Category code	IPCC Category	Gas	1990 estimate (kt CO_2-e)	2020 estimate (kt CO_2-e)	Trend assessment	Contribution to trend (%)	Cumulative total (%)
2.C.3	Metal Industry – Aluminium Production	PFCs	909.9	87.9	0.016	2.4	69.9
1.A.1.a	Energy Industries – Public Electricity and Heat Production Gaseous Fuels	CO_2	2,999.6	2,697.3	0.014	2.2	72.1
1.A.2.c	Manufacturing Industries and Construction – Chemicals Gaseous Fuels	CO_2	524.8	1,540.1	0.014	2.2	74.3
3.B.1.1	Option A – Dairy Cattle	CH_4	416.6	1,387.1	0.014	2.1	76.4
1.A.2.g.viii	Other (please specify) – Other (please specify) Solid Fuels	CO_2	731.1	35.3	0.013	2.0	78.4
1.A.2.e	Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco Solid Fuels	CO_2	938.6	1,702.0	0.009	1.4	79.7
1.A.2.e	Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco Gaseous Fuels	CO_2	443.4	1,086.7	0.008	1.3	81.1
3.H	Agriculture – Urea Application	CO_2	39.2	542.0	0.008	1.2	82.2
1.A.1.b	Energy Industries – Petroleum Refining Liquid Fuels	CO_2	778.9	543.8	0.006	0.9	83.2
1.A.3.a	Domestic Aviation – Jet Kerosene	CO_2	892.6	681.4	0.006	0.9	84.1
1.A.4.b	Other Sectors – Residential Solid Fuels	CO_2	344.9	28.4	0.006	0.9	85.1
1.B.1.a.1	Coal Mining and Handling – Underground Mines	CH_4	289.6	0.0	0.005	0.8	85.9
1.A.4.b	Other Sectors – Residential Liquid Fuels	CO_2	814.5	1,313.1	0.005	0.8	86.7
1.A.2.f	Manufacturing Industries and Construction – Non-metallic Minerals Solid Fuels	CO_2	382.9	178.4	0.004	0.7	87.4
1.A.2.g.iii	Other (please specify) – Mining (excluding fuels) and Quarrying Liquid Fuels	CO_2	94.1	365.4	0.004	0.6	88.0
3.A.4	Other Livestock – Goats	CH_4	196.6	21.6	0.003	0.5	88.5
3.D.1.3	Direct N_2O Emissions from Managed Soils – Urine and Dung Deposited by Grazing Animals	N_2O	3,068.6	3,890.0	0.003	0.4	88.9
1.B.2.d	Other (please specify) – Geothermal	CO_2	228.6	449.7	0.003	0.4	89.3
1.A.3.b	Transport – Road Transportation Gaseous Fuels	CO_2	140.3	0.0	0.003	0.4	89.7
1.A.4.b	Other Sectors – Residential Gaseous Fuels	CO_2	184.9	388.4	0.003	0.4	90.1
2.A.1	Mineral Industry – Cement Production	CO_2	448.7	379.2	0.003	0.4	90.5
1.A.2.g.v	Other (please specify) – Construction	CO_2	245.0	446.9	0.002	0.4	90.9
1.A.2.g.viii	Other (please specify) – Other (please specify) Liquid Fuels	CO_2	52.3	212.3	0.002	0.4	91.2
1.A.1.b	Energy Industries – Petroleum Refining Gaseous Fuels	CO_2	0.0	148.2	0.002	0.4	91.6
1.B.2.b.5	Natural Gas – Distribution	CH_4	277.5	192.2	0.002	0.3	91.9

IPCC Tier 1 category trend assessment – gross emissions (excluding LULUCF)							
CRF Category code	IPCC Category	Gas	1990 estimate (kt CO_2-e)	2020 estimate (kt CO_2-e)	Trend assessment	Contribution to trend (%)	Cumulative total (%)
1.A.4.a	Other Sectors – Commercial/ Institutional Gaseous Fuels	CO_2	235.2	426.6	0.002	0.3	92.3
1.A.4.c	Other Sectors – Agriculture/ Forestry/Fishing Solid Fuels	CO_2	35.1	171.8	0.002	0.3	92.6
3.D.1.6	Direct N_2O Emissions from Managed Soils – Cultivation of Organic Soils	N_2O	658.7	667.6	0.002	0.3	92.9
1.B.2.c.1.ii	Venting – Gas	CO_2	109.3	256.6	0.002	0.3	93.2
1.A.4.a	Other Sectors – Commercial/ Institutional Solid Fuels	CO_2	142.2	57.7	0.002	0.3	93.4
1.A.2.d	Manufacturing Industries and Construction – Pulp, Paper and Print Gaseous Fuels	CO_2	347.6	306.7	0.002	0.3	93.7
1.A.2.d	Manufacturing Industries and Construction – Pulp, Paper and Print Solid Fuels	CO_2	109.5	23.1	0.002	0.3	94.0
1.A.4.a	Other Sectors – Commercial/ Institutional Liquid Fuels	CO_2	500.7	707.9	0.002	0.2	94.2
5.C	Waste – Incineration and Open Burning of Waste	CO_2	158.9	89.8	0.002	0.2	94.5
3.B.1.2	CH_4 Emissions – Sheep	CH_4	148.8	91.9	0.001	0.2	94.7
1.A.1.a	Energy Industries – Public Electricity and Heat Production Liquid Fuels	CO_2	10.6	99.2	0.001	0.2	94.9
1.A.2.e	Manufacturing Industries and Construction – Food Processing, Beverages and Tobacco Liquid Fuels	CO_2	281.1	255.9	0.001	0.2	95.1
1.B.2.c.2.iii	Flaring – Combined	CO_2	114.1	54.2	0.001	0.2	95.3
1.B.2.c.1.iii	Venting – Combined	CH_4	93.8	32.6	0.001	0.2	95.5
2.F.4	Product Uses as Substitutes for ODS – Aerosols	HFCs	0.0	80.1	0.001	0.2	95.7
5.C	Waste – Incineration and Open Burning of Waste	CH_4	127.4	77.4	0.001	0.2	95.8
1.A.3.b	Transport – Road Transportation Liquid Fuels	CH_4	72.9	14.4	0.001	0.2	96.0
1.A.4.c	Other Sectors – Agriculture/ Forestry/Fishing Liquid Fuels	CO_2	1,071.4	1,362.6	0.001	0.2	96.2
1.B.2.c.2.iii	Flaring – Combined	CH_4	64.6	10.9	0.001	0.2	96.3
2.B.8	Chemical Industry – Petrochemical and Carbon Black Production	CH_4	27.6	96.1	0.001	0.1	96.5
3.B.2.5	N_2O and NMVOC Emissions – Indirect N_2O Emissions	N_2O	34.7	100.9	0.001	0.1	96.6
1.B.2.d	Other (please specify) – Geothermal	CH_4	54.8	118.4	0.001	0.1	96.8
1.A.4.c	Other Sectors – Agriculture/ Forestry/Fishing Gaseous Fuels	CO_2	105.8	76.5	0.001	0.1	96.9
3.G	Agriculture – Liming	CO_2	296.5	409.5	0.001	0.1	97.0
2.G.3	Other Product Manufacture and Use – N_2O from Product Uses	N_2O	102.4	73.9	0.001	0.1	97.1
2.B.10	Chemical Industry – Other (please specify)	CO_2	152.3	134.2	0.001	0.1	97.2
1.A.2.g.vi	Other (please specify) – Textile and Leather Gaseous Fuels	CO_2	58.9	22.1	0.001	0.1	97.4

IPCC Tier 1 category trend assessment – gross emissions (excluding LULUCF)							
CRF Category code	IPCC Category	Gas	1990 estimate (kt CO_2-e)	2020 estimate (kt CO_2-e)	Trend assessment	Contribution to trend (%)	Cumulative total (%)
1.A.3.b	Transport – Road Transportation Liquid Fuels	N_2O	89.3	61.1	0.001	0.1	97.5
3.D.1.4	Direct N_2O Emissions from Managed Soils – Crop Residues	N_2O	175.5	258.6	0.001	0.1	97.6
3.A.4	Other livestock – Deer	CH_4	445.5	497.6	0.001	0.1	97.7
3.D.2.2	Indirect N_2O Emissions from Managed Soils – Nitrogen Leaching and Run-off	N_2O	396.5	516.9	0.001	0.1	97.8
3.D.2.1	Indirect N_2O Emissions from Managed Soils – Atmospheric Deposition	N_2O	735.1	925.2	0.001	0.1	97.9
5.B	Waste – Biological Treatment of Solid Waste	CH_4	2.7	39.9	0.001	0.1	97.9
1.A.3.e	Transport – Other Transportation (please specify) Gaseous Fuels	CO_2	5.5	42.7	0.001	0.1	98.0
3.B.1.3	CH_4 Emissions – Swine	CH_4	58.6	34.8	0.001	0.1	98.1
1.A.2.g.i	Other (please specify) – Manufacturing of Machinery Gaseous Fuels	CO_2	41.8	14.6	0.001	0.1	98.2
1.A.3.a	Domestic Aviation – Aviation Gasoline	CO_2	47.7	22.4	0.001	0.1	98.3
3.A.4	Other livestock – Horses	CH_4	42.3	17.4	0.001	0.1	98.4
3.D.1.2	Direct N_2O Emissions from Managed Soils – Organic N Fertilizers	N_2O	36.3	76.2	0.000	0.1	98.4
1.B.2.b.2	Natural Gas – Production	CH_4	143.5	141.7	0.000	0.1	98.5
1.A.4.b	Other Sectors – Residential Solid Fuels	CH_4	27.3	2.2	0.000	0.1	98.6
1.A.2.f	Manufacturing Industries and Construction – Non-metallic Minerals Gaseous Fuels	CO_2	64.1	46.9	0.000	0.1	98.7
2.A.4	Mineral Industry – Other Process Uses of Carbonates	CO_2	30.5	66.8	0.000	0.1	98.7
5.B	Waste – Biological Treatment of Solid Waste	N_2O	2.0	28.5	0.000	0.1	98.8
5.D	Waste – Wastewater Treatment and Discharge	N_2O	82.0	120.4	0.000	0.1	98.9
1.A.2.g.vi	Other (please specify) – Textile and Leather Liquid Fuels	CO_2	19.3	2.3	0.000	0.1	98.9
1.A.2.a	Manufacturing Industries and Construction – Iron and Steel Gaseous Fuels	CO_2	116.2	119.5	0.000	0.0	99.0
1.A.3.c	Transport – Railways Liquid Fuels	CO_2	78.4	112.9	0.000	0.0	99.0
5.C	Waste – Incineration and Open Burning of Waste	N_2O	29.5	18.2	0.000	0.0	99.0

Note: Key categories are those that comprise 95 per cent of the total.

Annex 1: References

IPCC. 2006. Eggleston HS, Buendia L, Miwa K, Ngara T, Tanabe K (eds). *2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 1. General Guidance and Reporting.* IPCC National Greenhouse Gas Inventories Programme. Japan: Published for the IPCC by the Institute for Global Environmental Strategies.

Annex 2: Uncertainty analysis

Uncertainty estimates are an essential element of a complete greenhouse gas inventory. Uncertainty information helps prioritise efforts to improve the accuracy of inventories in the future and guides decisions on methodological choice.

New Zealand has followed Approach 1 for uncertainty analysis, as required by the inventory reporting guidelines under United Nations Framework Convention on Climate Change (UNFCCC, 2013) and Intergovernmental Panel on Climate Change (IPCC) methodological guidelines (IPCC, 2006). Uncertainties in the categories are combined in the uncertainty analysis to provide uncertainty estimates for the entire inventory in any year and the uncertainty in the overall inventory trend over time. Uncertainties for the categories themselves are described in the sector chapters 3 to 8 and chapter 11, as well as chapter 1 section 1.6.

A2.1 Approach 1 uncertainty calculation

The uncertainty in activity data and emission and/or removal factors presented in tables A2.1.1 and A2.1.2 are equal to half the 95 per cent confidence interval divided by the mean and expressed as a percentage. The reason for halving the 95 per cent confidence interval is that the value corresponds to the familiar plus or minus value when uncertainties are loosely quoted as ‘plus or minus x per cent’.

Where uncertainty is highly asymmetrical, the larger percentage difference between the mean and the confidence limit is entered. Where only the total uncertainty is known for a category, then:

- if uncertainty is correlated across years, the uncertainty is entered as the emission or the removal factor uncertainty and as zero in the activity data uncertainty
- if uncertainty is not correlated across years, the uncertainty is entered as the uncertainty in the activity data and as zero in the emission or the removal factor uncertainty.

In Approach 1, uncertainties in the trend are estimated using two sensitivities.

- Type A sensitivity is the change in the difference of total emissions between the base year and the current year, expressed as a percentage. Further, this change results from a 1 per cent increase in emissions of a given source category and a greenhouse gas in both the base year and the current year.
- Type B sensitivity is the change in the difference of total emissions between the base year and the current year, expressed as a percentage. Further, this change results from a 1 per cent increase in emissions of a given source category and gas in the current year only.

Uncertainties that are fully correlated between years are associated with Type A sensitivities, and uncertainties that are not correlated between years are associated with Type B sensitivities. Once the uncertainties introduced into the national inventory by Type A and Type B sensitivities have been calculated, they are summed using equation 3.1 (IPCC, 2006) to give the overall uncertainty in the trend.

In tables A2.1.1 and A2.1.2, the columns presenting trend uncertainties provide an estimate of the total uncertainty in the trend in emissions since the base year. This is expressed as the number of percentage points in the 95 per cent confidence interval in the per cent change in emissions since the base year. The values for individual categories are an estimate of the uncertainty introduced into the trend by the category in question.

In 2021 an internal review of the methods used to calculate the uncertainties was undertaken. The review identified an anomaly in the application of the methodology applied to the Land Use, Land-Use Change and Forestry (LULUCF) categories that comprised net removals, where they were converted to absolute values. This method resulted in reduced percentage uncertainty estimates for the base year, final year and trend, when compared with using unmodified values. The calculation method has been revised for this submission. The revision affects table A2.1.1 only.

Table A2.1.1 and table A2.1.2 present uncertainties for net emissions and gross emissions respectively.

Table A2.1.1 Uncertainty calculation (including LULUCF) for New Zealand’s Greenhouse Gas Inventory 1990–2020 (IPCC, 2006, Approach 1)

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO_2-e)	2020 emissions or absolute value of removals (kt CO_2-e)	Activity data uncertainty (%)	Emission or removal factor uncertainty (%)	Combined uncertainty (%)	Combined uncertainty as a per cent of the national total in 1990 (%)	Combined uncertainty as a per cent of the national total in 2020 (%)	Type A sensitivity (%)	Type B sensitivity (%)	Uncertainty in the trend in national total introduced by emission or removal factor uncertainty (%)	Uncertainty in trend in national total introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in the national total (%)	Combined uncertainty of the national total in 1990	Combined uncertainty of the national total in 2020
Energy – Gaseous fuels	CO_2	7,027.14	7,240.93	4.4	2.4	5.0	0.8022	0.6552	0.0369	0.1647	0.0889	1.0254	1.0292	0.64347159	0.42932808
Energy – Liquid fuels	CO_2	11,788.74	18,505.29	0.6	0.5	0.8	0.2069	0.2574	0.0824	0.4209	0.0412	0.3498	0.3522	0.04279611	0.06626591
Energy – Other fossil fuels	CO_2	0.02	0.35	5.0	5.0	7.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.00000000	0.00000000
Energy – Solid fuels	CO_2	32,11.03	4,022.06	3.0	2.2	3.7	0.2725	0.2706	0.0007	0.0915	0.0014	0.3924	0.3924	0.07426561	0.07321890
Energy – Fugitive – oil exploration	CO_2	0.00	0.00	0.6	100.0	100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Energy – Fugitive – oil production	CO_2	0.00	0.00	0.6	100.0	100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Energy – Fugitive – oil transport	CO_2	0.01	0.00	0.6	100.0	100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Energy – Fugitive – gas production	CO_2	0.21	0.20	4.4	100.0	100.1	0.0005	0.0004	0.0000	0.0000	0.0001	0.0000	0.0001	0.00000022	0.00000013
Energy – Fugitive – gas transmission and storage	CO_2	0.01	0.03	4.4	100.0	100.1	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Energy – Fugitive – gas distribution	CO_2	1.45	1.17	4.4	100.0	100.1	0.0033	0.0021	0.0000	0.0000	0.0015	0.0002	0.0015	0.00001089	0.00000442
Energy – Fugitive – venting and flaring	CO_2	229.48	329.64	4.4	2.4	5.0	0.0262	0.0298	0.0009	0.0075	0.0022	0.0467	0.0467	0.00068621	0.00088977
Energy – Fugitive – other forms of energy production	CO_2	228.58	449.69	5.0	5.0	7.1	0.0368	0.0573	0.0037	0.0102	0.0183	0.0723	0.0746	0.00135134	0.00328661
2.A.1 Cement production	CO_2	448.75	379.16	1.0	1.0	1.4	0.0	0.0	0.0043	0.0086	0.0043	0.0122	0.0129	0.00020834	0.00009346
2.A.2 Lime production	CO_2	82.60	91.45	2.0	2.0	2.8	0.0	0.0	0.0003	0.0021	0.0006	0.0059	0.0059	0.00002823	0.00002175
2.A.4.a Ceramics	CO_2	0.01	0.01	50.0	20.0	53.9	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
2.A.4.b Other uses of soda ash	CO_2	5.87	6.19	3.0	2.0	3.6	0.0	0.0	0.0000	0.0001	0.0001	0.0006	0.0006	0.00000023	0.00000016
2.A.4.d Other – Other uses of limestone	CO_2	24.63	60.62	3.0	2.0	3.6	0.0	0.0	0.0007	0.0014	0.0013	0.0058	0.0060	0.00000408	0.00001553
2.B.1 Ammonia production	CO_2	21.68	18.75	2.0	6.0	6.3	0.0	0.0	0.0002	0.0004	0.0012	0.0012	0.0017	0.00000973	0.00000457
2.B.5.b Calcium carbide	CO_2	1.43	1.43	50.0	50.0	70.7	0.0	0.0	0.0000	0.0000	0.0004	0.0023	0.0023	0.00000529	0.00000332
2.B.10 Hydrogen production	CO_2	152.29	134.19	2.0	6.0	6.3	0.0	0.0	0.0013	0.0031	0.0079	0.0086	0.0117	0.00047987	0.00023415
2.C.1 Iron and steel	CO_2	1,306.73	1,578.55	5.0	7.0	8.6	0.3	0.2	0.0016	0.0359	0.0111	0.2539	0.2541	0.06536390	0.05993923
2.C.3.a Aluminium	CO_2	448.98	549.22	5.0	2.0	5.4	0.1	0.1	0.0004	0.0125	0.0008	0.0883	0.0883	0.00302401	0.00284353
2.C.5 Secondary lead production	CO_2	1.80	0.00	50.0	50.0	70.7	0.0	0.0	0.0001	0.0000	0.0026	0.0000	0.0026	0.00000838	0.00000000
2.D.1 Lubricant use	CO_2	22.83	38.26	20.0	50.0	53.9	0.0	0.0	0.0002	0.0009	0.0108	0.0246	0.0269	0.00078163	0.00138001
2.D.2 Paraffin wax	CO_2	2.35	2.35	20.0	100.0	102.0	0.0	0.0	0.0000	0.0001	0.0014	0.0015	0.0021	0.00002964	0.00001863

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2.D.3 Other – Urea catalyst in road transport	CO_2	0.00	3.48	50.0	10.0	51.0	0.0	0.0	0.0001	0.0001	0.0008	0.0056	0.0056	0.00000000	0.00001021
Agriculture – Liming	CO_2	296.48	409.48	3.4	50.0	50.1	0.3	0.4	0.0008	0.0093	0.0403	0.0448	0.0603	0.11420305	0.13688776
Agriculture – Urea application	CO_2	39.19	542.03	10.0	50.0	51.0	0.0	0.5	0.0112	0.0123	0.5602	0.1743	0.5867	0.00206616	0.24830108
LULUCF – Forest land	CO_2	–20,299.82	–19,983.31	0.0	61.6	61.6	-28.4	-22.2	0.1285	0.4545	7.9137	0.0000	7.9137	808.18293336	492.14016610
LULUCF – Cropland	CO_2	468.69	375.55	0.0	70.5	70.5	0.8	0.5	0.0049	0.0085	0.3456	0.0000	0.3456	0.56399774	0.22755382
LULUCF – Grassland	CO_2	609.84	2,524.46	0.0	44.9	44.9	0.6	2.0	0.0399	0.0574	1.7940	0.0000	1.7940	0.38864940	4.18490918
LULUCF – Wetlands	CO_2	–10.47	13.31	0.0	108.9	108.9	0.0	0.0	0.0006	0.0003	0.0657	0.0000	0.0657	0.00067240	0.00068256
LULUCF – Settlements	CO_2	75.42	124.05	0.0	61.6	61.6	0.1	0.1	0.0007	0.0028	0.0405	0.0000	0.0405	0.01115040	0.01895480
LULUCF – Other Land	CO_2	13.50	114.28	0.0	86.4	86.4	0.0	0.2	0.0022	0.0026	0.1912	0.0000	0.1912	0.00070372	0.03170488
LULUCF – Harvested wood products	CO_2	–2,481.21	–6,834.58	0.0	68.2	68.2	-3.9	-8.4	0.0843	0.1554	5.7527	0.0000	5.7527	14.82923474	70.70384240
Waste – Incineration and open burning of waste	CO_2	158.91	89.80	50.0	40.0	64.0	0.2	0.1	0.0025	0.0020	0.1007	0.1444	0.1760	0.05355820	0.01074726
Tokelau Energy Industries – Sectoral approach – liquid	CO_2	0.23	0.23	10.0	7.0	12.2	0.0	0.0	0.0000	0.0000	0.0000	0.0001	0.0001	0.00000000	0.00000000
Tokelau Gas Diesel Oil – Sectoral approach – liquid	CO_2	0.90	2.05	50.0	1.5	50.0	0.0	0.0	0.0000	0.0000	0.0000	0.0033	0.0033	0.00000104	0.00000343
Tokelau Other/Residential – Sectoral approach – liquid	CO_2	0.12	0.10	20.0	7.0	21.2	0.0	0.0	0.0000	0.0000	0.0000	0.0001	0.0001	0.00000000	0.00000000
Tokelau Waste – Incineration and open burning of waste	CO_2	0.05	0.04	50.0	40.0	64.0	0.0	0.0	0.0000	0.0000	0.0000	0.0001	0.0001	0.00000000	0.00000000
Energy – Gaseous fuels	CH_4	9.05	4.43	4.4	50.0	50.2	0.0	0.0	0.0002	0.0001	0.0080	0.0006	0.0080	0.00010675	0.00001604
Energy – Liquid fuels	CH_4	87.51	34.57	0.6	50.0	50.0	0.1	0.0	0.0017	0.0008	0.0862	0.0007	0.0862	0.00990540	0.00097125
Energy – Other fossil fuels	CH_4	0.01	0.01	5.0	50.0	50.2	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Energy – Solid fuels	CH_4	36.37	21.17	3.0	50.0	50.1	0.0	0.0	0.0006	0.0005	0.0281	0.0021	0.0282	0.00171648	0.00036566
Energy – Biomass	CH_4	69.44	64.48	50.0	50.0	70.7	0.1	0.1	0.0005	0.0015	0.0263	0.1037	0.1070	0.01247075	0.00675734
Energy – Fugitive – coal handling	CH_4	328.03	61.38	3.0	50.0	50.1	0.4	0.1	0.0080	0.0014	0.4008	0.0060	0.4008	0.13966923	0.00307258
Energy – Fugitive – oil exploration	CH_4	0.00	0.00	0.6	50.0	50.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Energy – Fugitive – oil production	CH_4	0.06	0.03	0.6	50.0	50.0	0.0	0.0	0.0000	0.0000	0.0001	0.0000	0.0001	0.00000001	0.00000000
Energy – Fugitive – oil transport	CH_4	1.68	0.94	0.6	50.0	50.0	0.0	0.0	0.0000	0.0000	0.0013	0.0000	0.0013	0.00000366	0.00000071
Energy – Fugitive – oil refining	CH_4	2.73	2.53	0.6	50.0	50.0	0.0	0.0	0.0000	0.0001	0.0010	0.0000	0.0010	0.00000963	0.00000519

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Energy – Fugitive – gas production	CH_4	143.45	141.67	4.4	50.0	50.2	0.2	0.1	0.0009	0.0032	0.0447	0.0201	0.0490	0.02681884	0.01643721
Energy – Fugitive – gas transmission and storage	CH_4	2.47	6.09	4.4	100.0	100.1	0.0	0.0	0.0001	0.0001	0.0067	0.0009	0.0068	0.00003170	0.00012065
Energy – Fugitive – gas distribution	CH_4	277.49	192.24	4.4	100.0	100.1	0.6	0.3	0.0036	0.0044	0.3589	0.0272	0.3599	0.39907249	0.12035600
Energy – Fugitive – venting and flaring	CH_4	158.42	43.51	4.4	50.0	50.2	0.2	0.0	0.0036	0.0010	0.1778	0.0062	0.1779	0.03270771	0.00155020
Energy – Fugitive – other forms of energy production	CH_4	54.79	118.36	5.0	50.0	50.2	0.1	0.1	0.0011	0.0027	0.0560	0.0190	0.0591	0.00392119	0.01149737
2.B.8 Methanol	CH_4	27.60	96.15	2.0	80.0	80.0	0.1	0.1	0.0014	0.0022	0.1116	0.0062	0.1118	0.00252349	0.01924466
Agriculture – Enteric fermentation	CH_4	27,350.37	28,831.52	3.9	15.5	16.0	10.0	8.3	0.1282	0.6557	1.9890	3.6167	4.1276	99.05987878	69.17280390
Agriculture – Manure management	CH_4	727.81	1,620.51	5.0	20.0	20.6	0.3	0.6	0.0160	0.0369	0.3194	0.2606	0.4123	0.11645555	0.36278590
Agriculture – Burning of residues	CH_4	22.62	19.97	6.0	20.0	20.9	0.0	0.0	0.0002	0.0005	0.0039	0.0039	0.0055	0.00011542	0.00005654
CH_4 emissions associated with biomass burning (CO_2-e)	CH_4	68.71	81.66	30.0	41.6	51.3	0.1	0.1	0.0001	0.0019	0.0048	0.0788	0.0789	0.00642435	0.00570131
Waste –Solid waste disposal	CH_4	3,318.21	2,637.66	88.4	40.0	97.0	7.3	4.6	0.0352	0.0600	1.4075	7.4996	7.6305	53.61881152	21.29005206
Waste – Wastewater treatment and discharge	CH_4	222.51	256.94	10.0	40.0	41.2	0.2	0.2	0.0005	0.0058	0.0216	0.0826	0.0854	0.04354017	0.03648257
Waste – Biological treatment of solid waste	CH_4	2.74	39.92	100.0	100.0	141.4	0.0	0.1	0.0008	0.0009	0.0829	0.1284	0.1528	0.00007754	0.01035807
Waste – Incineration and open burning of waste	CH_4	127.35	77.41	50.0	100.0	111.8	0.3	0.2	0.0019	0.0018	0.1893	0.1245	0.2266	0.10487393	0.02435020
Tokelau Energy Industries – Sectoral approach – liquid	CH_4	0.00	0.00	10.0	50.0	51.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Tokelau Gas Diesel Oil – Sectoral approach – liquid	CH_4	0.00	0.00	50.0	50.0	70.7	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Tokelau Other/Residential – Sectoral approach – liquid	CH_4	0.00	0.00	20.0	50.0	53.9	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Tokelau Agriculture – Enteric fermentation	CH_4	0.09	0.06	20.0	50.0	53.9	0.0	0.0	0.0000	0.0000	0.0001	0.0000	0.0001	0.00000001	0.00000000
Tokelau Agriculture – Manure management	CH_4	1.06	0.76	20.0	30.0	36.1	0.0	0.0	0.0000	0.0000	0.0004	0.0005	0.0006	0.00000076	0.00000025
Tokelau Waste – Solid waste disposal	CH_4	0.39	0.31	140.0	40.0	145.6	0.0	0.0	0.0000	0.0000	0.0002	0.0014	0.0014	0.00000170	0.00000065

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Tokelau Waste – Wastewater treatment and discharge	CH_4	0.15	0.27	10.0	40.0	41.2	0.0	0.0	0.0000	0.0000	0.0001	0.0001	0.0001	0.00000002	0.00000004
Tokelau Waste – Incineration and open burning of waste	CH_4	0.09	0.07	50.0	100.0	111.8	0.0	0.0	0.0000	0.0000	0.0001	0.0001	0.0001	0.00000005	0.00000002
Energy – Gaseous fuels	N_2O	5.53	3.66	4.4	50.0	50.2	0.0	0.0	0.0001	0.0001	0.0038	0.0005	0.0038	0.00003986	0.00001094
Energy – Liquid fuels	N_2O	157.91	156.16	0.6	50.0	50.0	0.2	0.1	0.0010	0.0036	0.0490	0.0030	0.0490	0.03225197	0.01981894
Energy – Other fossil fuels	N_2O	0.21	0.24	5.0	50.0	50.2	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000006	0.00000005
Energy – Solid fuels	N_2O	14.93	18.49	3.0	50.0	50.1	0.0	0.0	0.0000	0.0004	0.0004	0.0018	0.0018	0.00028934	0.00027895
Energy – Biomass	N_2O	41.09	42.11	50.0	50.0	70.7	0.1	0.1	0.0002	0.0010	0.0111	0.0677	0.0686	0.00436653	0.00288217
Energy – Fugitive – venting and flaring	N_2O	0.06	0.03	4.4	100.0	100.1	0.0	0.0	0.0000	0.0000	0.0001	0.0000	0.0001	0.00000002	0.00000000
2.G.3 N_2O from product uses	N_2O	102.45	73.87	15.0	0.0	15.0	0.0	0.0	0.0013	0.0017	0.0000	0.0356	0.0356	0.00122152	0.00039914
Agriculture – Agricultural soils	N_2O	5,300.94	7,882.85	11.4	54.1	55.3	6.7	7.9	0.0272	0.1793	1.4698	2.8927	3.2447	44.45245019	61.77111567
Agriculture – Manure management	N_2O	50.69	115.06	5.0	100.0	100.1	0.1	0.2	0.0012	0.0026	0.1162	0.0185	0.1177	0.01332565	0.04314088
Agriculture – Burning of residues	N_2O	4.77	4.13	6.0	20.0	20.9	0.0	0.0	0.0000	0.0001	0.0009	0.0008	0.0012	0.00000512	0.00000241
Direct and indirect N_2O emissions (CO_2-e)	N_2O	300.27	220.33	0.0	58.5	58.5	0.4	0.2	0.0036	0.0050	0.2108	0.0000	0.2108	0.15963190	0.05400783
N_2O emissions associated with biomass burning (CO_2-e)	N_2O	25.85	50.99	30.0	41.6	51.3	0.0	0.0	0.0004	0.0012	0.0174	0.0492	0.0522	0.00090919	0.00222304
Waste – Wastewater treatment and discharge	N_2O	81.98	120.41	10.0	90.0	90.6	0.2	0.2	0.0004	0.0027	0.0348	0.0387	0.0521	0.02850650	0.03864613
Waste – Incineration and open burning of waste	N_2O	29.46	18.18	50.0	100.0	111.8	0.1	0.0	0.0004	0.0004	0.0432	0.0292	0.0521	0.00561066	0.00134295
Waste – Biological treatment of solid waste	N_2O	1.96	28.55	100.0	150.0	180.3	0.0	0.1	0.0006	0.0006	0.0890	0.0918	0.1279	0.00006446	0.00860968
Tokelau Energy Industries – Sectoral approach – liquid	N_2O	0.00	0.00	10.0	50.0	51.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Tokelau Gas Diesel Oil – Sectoral approach – liquid	N_2O	0.01	0.02	50.0	50.0	70.7	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Tokelau Other/Residential – Sectoral approach – liquid	N_2O	0.00	0.00	20.0	50.0	53.9	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Tokelau IPPU – Other product manufacture and use	N_2O	0.05	0.02	15.0	0.0	15.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000

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Tokelau Waste – Wastewater treatment and discharge	N_2O	0.02	0.00	10.0	90.0	90.6	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Tokelau Waste – Incineration and open burning of waste	N_2O	0.01	0.01	50.0	100.0	111.8	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
2.F.1 Refrigeration and air conditioning	HFCs	0.00	1,391.56	34.0	0.0	34.0	0.0	0.9	0.0316	0.0316	0.0000	1.5218	1.5218	0.00000000	0.72764902
2.F.2 Foam blowing agents	HFCs	0.00	6.23	12.0	50.0	51.4	0.0	0.0	0.0001	0.0001	0.0071	0.0024	0.0075	0.00000000	0.00003332
2.F.3 Fire protection	HFCs	0.00	2.18	10.0	41.0	42.2	0.0	0.0	0.0000	0.0000	0.0020	0.0007	0.0021	0.00000000	0.00000274
2.F.4 Aerosols	HFCs	0.00	80.09	30.0	30.0	42.4	0.0	0.1	0.0018	0.0018	0.0546	0.0773	0.0947	0.00000000	0.00375347
2.C.3.a Aluminium	PFCs	909.95	87.91	5.0	30.0	30.4	0.6	0.0	0.0241	0.0020	0.7231	0.0141	0.7232	0.39619359	0.00232352
2.F.1 Refrigeration and air conditioning	PFCs	0.00	0.00	25.0	0.0	25.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
2.G.2 Other product use	PFCs	0.00	0.01	80.0	0.0	80.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
2.C.4 Magnesium production	SF_6	2.74	0.00	100.0	0.0	100.0	0.0	0.0	0.0001	0.0000	0.0000	0.0000	0.0000	0.00003872	0.00000000
2.G.1 Electrical equipment	SF_6	14.50	13.95	20.0	30.0	36.1	0.0	0.0	0.0001	0.0003	0.0030	0.0090	0.0095	0.00014140	0.00008223
2.G.2 Other product use	SF_6	2.74	2.74	80.0	0.0	80.0	0.0	0.0	0.0000	0.0001	0.0000	0.0070	0.0070	0.00002478	0.00001557
Tokelau IPPU – Product uses as substitutes for ODS	HFCs	0.00	0.23	44.0	0.0	44.0	0.0	0.0	0.0000	0.0000	0.0000	0.0003	0.0003	0.00000000	0.00000003
Total emissions/removals		**43,967.76**	**55,465.11**			**Uncertainty in the base year**	**32.0%**		**Uncertainty in the final year**		**26.9%**		**Uncertainty in the trend**	**13.8%**	

Table A2.1.2 Uncertainty calculation (excluding LULUCF) for New Zealand's Greenhouse Gas Inventory 1990–2020 (IPCC, 2006, Approach 1)

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO_2-e)	2020 emissions or absolute value of removals (kt CO_2-e)	Activity data uncertainty (%)	Emission or removal factor uncertainty (%)	Combined uncertainty (%)	Combined uncertainty as a per cent of the national total in 2020 (%)	Combined uncertainty as a per cent of the national total in the last year (%)	Type A sensitivity (%)	Type B sensitivity (%)	Uncertainty in the trend in national total introduced by emission or removal factor uncertainty (%)	Uncertainty in trend in national total introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in the national total (%)	Combined uncertainty of the national total in 1990	Combined uncertainty of the national total in the last year
Energy – Gaseous fuels	CO_2	7,027.14	7,240.93	4.4	2.4	5.0	0.5410	0.4613	0.0192	0.1111	0.0462	0.6915	0.6930	0.29264636	0.21282132
Energy – Liquid fuels	CO_2	11,788.74	18,505.29	0.6	0.5	0.8	0.1395	0.1812	0.0652	0.2838	0.0326	0.2359	0.2381	0.01946337	0.03284853
Energy – Other fossil fuels	CO_2	0.02	0.35	5.0	5.0	7.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Energy – Solid fuels	CO_2	32,11.03	4,022.06	3.0	2.2	3.7	0.1838	0.1905	0.0022	0.0617	0.0047	0.2646	0.2646	0.03377548	0.03629519
Energy – Fugitive – oil exploration	CO_2	0.00	0.00	0.6	100.0	100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Energy – Fugitive – oil production	CO_2	0.00	0.00	0.6	100.0	100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Energy – Fugitive – oil transport	CO_2	0.01	0.00	0.6	100.0	100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Energy – Fugitive – gas production	CO_2	0.21	0.20	4.4	100.0	100.1	0.0003	0.0003	0.0000	0.0000	0.0001	0.0000	0.0001	0.00000010	0.00000007
Energy – Fugitive – gas transmission and storage	CO_2	0.01	0.03	4.4	100.0	100.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Energy – Fugitive – gas distribution	CO_2	1.45	1.17	4.4	100.0	100.1	0.0022	0.0015	0.0000	0.0000	0.0009	0.0001	0.0009	0.00000495	0.00000219
Energy – Fugitive – venting and flaring	CO_2	229.48	329.64	4.4	2.4	5.0	0.0177	0.0210	0.0008	0.0051	0.0019	0.0315	0.0315	0.00031208	0.00044107
Energy – Fugitive – other forms of energy production	CO_2	228.58	449.69	5.0	5.0	7.1	0.0248	0.0404	0.0027	0.0069	0.0133	0.0488	0.0506	0.00061458	0.00162920
2.A.1 Cement production	CO_2	448.75	379.16	1.0	1.0	1.4	0.0	0.0	0.0025	0.0058	0.0025	0.0082	0.0086	0.00009475	0.00004633
2.A.2 Lime production	CO_2	82.60	91.45	2.0	2.0	2.8	0.0	0.0	0.0001	0.0014	0.0003	0.0040	0.0040	0.00001284	0.00001078
2.A.4.a Ceramics	CO_2	0.01	0.01	50.0	20.0	53.9	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
2.A.4.b Other uses of soda ash	CO_2	5.87	6.19	3.0	2.0	3.6	0.0	0.0	0.0000	0.0001	0.0000	0.0004	0.0004	0.00000011	0.00000008
2.A.4.d Other – Other uses of limestone	CO_2	24.63	60.62	3.0	2.0	3.6	0.0	0.0	0.0005	0.0009	0.0009	0.0039	0.0041	0.00000186	0.00000770
2.B.1 Ammonia production	CO_2	21.68	18.75	2.0	6.0	6.3	0.0	0.0	0.0001	0.0003	0.0007	0.0008	0.0011	0.00000442	0.00000227
2.B.5.b Calcium carbide	CO_2	1.43	1.43	50.0	50.0	70.7	0.0	0.0	0.0000	0.0000	0.0002	0.0016	0.0016	0.00000241	0.00000165
2.B.10 Hydrogen production	CO_2	152.29	134.19	2.0	6.0	6.3	0.0	0.0	0.0008	0.0021	0.0046	0.0058	0.0074	0.00021824	0.00011607
2.C.1 Iron and steel	CO_2	1,306.73	1,578.55	5.0	7.0	8.6	0.2	0.2	0.0000	0.0242	0.0000	0.1712	0.1712	0.02972704	0.02971235
2.C.3.a Aluminium	CO_2	448.98	549.22	5.0	2.0	5.4	0.0	0.0	0.0001	0.0084	0.0002	0.0596	0.0596	0.00137530	0.00140956

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO_2-e)	2020 emissions or absolute value of removals (kt CO_2-e)	Activity data uncertainty (%)	Emission or removal factor uncertainty (%)	Combined uncertainty (%)	Combined uncertainty as a per cent of the national total in 2020 (%)	Combined uncertainty as a per cent of the national total in the last year (%)	Type A sensitivity (%)	Type B sensitivity (%)	Uncertainty in the trend in national total introduced by emission or removal factor uncertainty (%)	Uncertainty in trend in national total introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in the national total (%)	Combined uncertainty of the national total in 1990	Combined uncertainty of the national total in the last year
2.C.5 Secondary lead production	CO_2	1.80	0.00	50.0	50.0	70.7	0.0	0.0	0.0000	0.0000	0.0017	0.0000	0.0017	0.00000381	0.00000000
2.D.1 Lubricant use	CO_2	22.83	38.26	20.0	50.0	53.9	0.0	0.0	0.0002	0.0006	0.0082	0.0166	0.0185	0.00035548	0.00068408
2.D.2 Paraffin wax	CO_2	2.35	2.35	20.0	100.0	102.0	0.0	0.0	0.0000	0.0000	0.0007	0.0010	0.0013	0.00001348	0.00000923
2.D.3 Other: Urea catalyst in road transport	CO_2	0.00	3.48	50.0	10.0	51.0	0.0	0.0	0.0001	0.0001	0.0005	0.0038	0.0038	0.00000000	0.00000506
Agriculture – Liming	CO_2	296.48	409.48	3.4	50.0	50.1	0.2	0.3	0.0008	0.0063	0.0393	0.0302	0.0496	0.05193875	0.06785634
Agriculture – Urea application	CO_2	39.19	542.03	10.0	50.0	51.0	0.0	0.4	0.0076	0.0083	0.3794	0.1176	0.3972	0.00093968	0.12308481
Waste – Incineration and open burning of waste	CO_2	158.91	89.80	50.0	40.0	64.0	0.2	0.1	0.0016	0.0014	0.0627	0.0974	0.1158	0.02435789	0.00532750
Tokelau Energy Industries – Sectoral approach – liquid	CO_2	0.23	0.23	10.0	7.0	12.2	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Tokelau Gas Diesel Oil – Sectoral approach – liquid	CO_2	0.90	2.05	50.0	1.5	50.0	0.0	0.0	0.0000	0.0000	0.0000	0.0022	0.0022	0.00000047	0.00000170
Tokelau Other/Residential – Sectoral approach – liquid	CO_2	0.12	0.10	20.0	7.0	21.2	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Tokelau Waste – Incineration and open burning of waste	CO_2	0.05	0.04	50.0	40.0	64.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Energy – Gaseous fuels	CH_4	9.05	4.43	4.4	50.0	50.2	0.0	0.0	0.0001	0.0001	0.0050	0.0004	0.0050	0.00004855	0.00000795
Energy – Liquid fuels	CH_4	87.51	34.57	0.6	50.0	50.0	0.1	0.0	0.0011	0.0005	0.0546	0.0004	0.0546	0.00450491	0.00048146
Energy – Other fossil fuels	CH_4	0.01	0.01	5.0	50.0	50.2	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Energy – Solid fuels	CH_4	36.37	21.17	3.0	50.0	50.1	0.0	0.0	0.0003	0.0003	0.0175	0.0014	0.0175	0.00078064	0.00018126
Energy – Biomass	CH_4	69.44	64.48	50.0	50.0	70.7	0.1	0.1	0.0003	0.0010	0.0149	0.0699	0.0715	0.00567161	0.00334967
Energy – Fugitive – coal handling	CH_4	328.03	61.38	3.0	50.0	50.1	0.3	0.0	0.0051	0.0009	0.2569	0.0040	0.2569	0.06352059	0.00152310
Energy – Fugitive – oil exploration	CH_4	0.00	0.00	0.6	50.0	50.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Energy – Fugitive – oil production	CH_4	0.06	0.03	0.6	50.0	50.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Energy – Fugitive – oil transport	CH_4	1.68	0.94	0.6	50.0	50.0	0.0	0.0	0.0000	0.0000	0.0008	0.0000	0.0008	0.00000166	0.00000035
Energy – Fugitive – oil refining	CH_4	2.73	2.53	0.6	50.0	50.0	0.0	0.0	0.0000	0.0000	0.0006	0.0000	0.0006	0.00000438	0.00000257
Energy – Fugitive – gas production	CH_4	143.45	141.67	4.4	50.0	50.2	0.1	0.1	0.0005	0.0022	0.0243	0.0135	0.0278	0.01219702	0.00814805

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO_2-e)	2020 emissions or absolute value of removals (kt CO_2-e)	Activity data uncertainty (%)	Emission or removal factor uncertainty (%)	Combined uncertainty (%)	Combined uncertainty as a per cent of the national total in 2020 (%)	Combined uncertainty as a per cent of the national total in the last year (%)	Type A sensitivity (%)	Type B sensitivity (%)	Uncertainty in the trend in national total introduced by emission or removal factor uncertainty (%)	Uncertainty in trend in national total introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in the national total (%)	Combined uncertainty of the national total in 1990	Combined uncertainty of the national total in the last year
Energy – Fugitive – gas transmission and storage	CH_4	2.47	6.09	4.4	100.0	100.1	0.0	0.0	0.0000	0.0001	0.0048	0.0006	0.0048	0.00001442	0.00005981
Energy – Fugitive – gas distribution	CH_4	277.49	192.24	4.4	100.0	100.1	0.4	0.2	0.0022	0.0029	0.2194	0.0184	0.2202	0.18149537	0.05966142
Energy – Fugitive – venting and flaring	CH_4	158.42	43.51	4.4	50.0	50.2	0.1	0.0	0.0023	0.0007	0.1134	0.0042	0.1135	0.01487524	0.00076845
Energy – Fugitive – other forms of energy production	CH_4	54.79	118.36	5.0	50.0	50.2	0.0	0.1	0.0008	0.0018	0.0400	0.0128	0.0420	0.00178333	0.00569934
2.B.8 Methanol	CH_4	27.60	96.15	2.0	80.0	80.0	0.0	0.1	0.0010	0.0015	0.0771	0.0042	0.0772	0.00114766	0.00953973
Agriculture – Enteric fermentation	CH_4	27,350.37	28,831.52	3.9	15.5	16.0	6.7	5.9	0.0644	0.4422	0.9993	2.4390	2.6358	45.05173791	34.28950480
Agriculture – Manure management	CH_4	727.81	1,620.51	5.0	20.0	20.6	0.2	0.4	0.0114	0.0249	0.2273	0.1758	0.2873	0.05296317	0.17983583
Agriculture – Burning of residues	CH_4	22.62	19.97	6.0	20.0	20.9	0.0	0.0	0.0001	0.0003	0.0023	0.0026	0.0034	0.00005249	0.00002803
Waste – Solid waste disposal	CH_4	3,318.21	2,637.66	88.4	40.0	97.0	4.9	3.2	0.0210	0.0405	0.8412	5.0576	5.1271	24.38545932	10.55364682
Waste – Wastewater treatment and discharge	CH_4	222.51	256.94	10.0	40.0	41.2	0.1	0.1	0.0002	0.0039	0.0073	0.0557	0.0562	0.01980176	0.01808470
Waste – Biological treatment of solid waste	CH_4	2.74	39.92	100.0	100.0	141.4	0.0	0.1	0.0006	0.0006	0.0561	0.0866	0.1032	0.00003527	0.00513458
Waste – Incineration and open burning of waste	CH_4	127.35	77.41	50.0	100.0	111.8	0.2	0.1	0.0012	0.0012	0.1173	0.0840	0.1442	0.04769593	0.01207059
Tokelau Energy industries – Sectoral approach – liquid	CH_4	0.00	0.00	10.0	50.0	51.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Tokelau Gas Diesel Oil – Sectoral approach – liquid	CH_4	0.00	0.00	50.0	50.0	70.7	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Tokelau Other/Residential – Sectoral approach – liquid	CH_4	0.00	0.00	20.0	50.0	53.9	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Tokelau Agriculture – Enteric fermentation	CH_4	0.09	0.06	20.0	50.0	53.9	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000001	0.00000000
Tokelau Agriculture – Manure management	CH_4	1.06	0.76	20.0	30.0	36.1	0.0	0.0	0.0000	0.0000	0.0002	0.0003	0.0004	0.00000035	0.00000012
Tokelau Waste – Solid waste disposal	CH_4	0.39	0.31	140.0	40.0	145.6	0.0	0.0	0.0000	0.0000	0.0001	0.0009	0.0009	0.00000077	0.00000032

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO_2-e)	2020 emissions or absolute value of removals (kt CO_2-e)	Activity data uncertainty (%)	Emission or removal factor uncertainty (%)	Combined uncertainty (%)	Combined uncertainty as a per cent of the national total in 2020 (%)	Combined uncertainty as a per cent of the national total in the last year (%)	Type A sensitivity (%)	Type B sensitivity (%)	Uncertainty in the trend in national total introduced by emission or removal factor uncertainty (%)	Uncertainty in trend in national total introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in the national total (%)	Combined uncertainty of the national total in 1990	Combined uncertainty of the national total in the last year
Tokelau Waste – Wastewater treatment and discharge	CH_4	0.15	0.27	10.0	40.0	41.2	0.0	0.0	0.0000	0.0000	0.0001	0.0001	0.0001	0.00000001	0.00000002
Tokelau Waste – Incineration and open burning of waste	CH_4	0.09	0.07	50.0	100.0	111.8	0.0	0.0	0.0000	0.0000	0.0001	0.0001	0.0001	0.00000002	0.00000001
Energy – Gaseous fuels	N_2O	5.53	3.66	4.4	50.0	50.2	0.0	0.0	0.0000	0.0001	0.0023	0.0003	0.0023	0.00001813	0.00000542
Energy – Liquid fuels	N_2O	157.91	156.16	0.6	50.0	50.0	0.1	0.1	0.0005	0.0024	0.0266	0.0020	0.0266	0.01466797	0.00982440
Energy – Other fossil fuels	N_2O	0.21	0.24	5.0	50.0	50.2	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000003	0.00000002
Energy – Solid fuels	N_2O	14.93	18.49	3.0	50.0	50.1	0.0	0.0	0.0000	0.0003	0.0003	0.0012	0.0013	0.00013159	0.00013828
Energy – Biomass	N_2O	41.09	42.11	50.0	50.0	70.7	0.0	0.0	0.0001	0.0006	0.0058	0.0457	0.0460	0.00198587	0.00142872
Energy – Fugitive – venting and flaring	N_2O	0.06	0.03	4.4	100.0	100.1	0.0	0.0	0.0000	0.0000	0.0001	0.0000	0.0001	0.00000001	0.00000000
2.G.3 N_2O from product uses	N_2O	102.45	73.87	15.0	0.0	15.0	0.0	0.0	0.0008	0.0011	0.0000	0.0240	0.0240	0.00055554	0.00019786
Agriculture – Agricultural soils	N_2O	5300.94	7882.85	11.4	54.1	55.3	4.5	5.5	0.0226	0.1209	1.2254	1.9508	2.3038	20.21666249	30.62042953
Agriculture – Manure management	N_2O	50.69	115.06	5.0	100.0	100.1	0.1	0.1	0.0008	0.0018	0.0825	0.0125	0.0835	0.00606041	0.02138527
Agriculture – Burning of residues	N_2O	4.77	4.13	6.0	20.0	20.9	0.0	0.0	0.0000	0.0001	0.0005	0.0005	0.0007	0.00000233	0.00000120
Waste – Wastewater treatment and discharge	N_2O	81.98	120.41	10.0	90.0	90.6	0.1	0.1	0.0003	0.0018	0.0295	0.0261	0.0394	0.01296456	0.01915719
Waste – Incineration and open burning of waste	N_2O	29.46	18.18	50.0	100.0	111.8	0.1	0.0	0.0003	0.0003	0.0267	0.0197	0.0332	0.00255169	0.00066571
Waste – Biological treatment of solid waste	N_2O	1.96	28.55	100.0	150.0	180.3	0.0	0.1	0.0004	0.0004	0.0602	0.0619	0.0864	0.00002931	0.00426789
Tokelau Energy Industries – Sectoral approach – liquid	N_2O	0.00	0.00	10.0	50.0	51.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Tokelau Gas Diesel Oil – Sectoral approach – liquid	N_2O	0.01	0.02	50.0	50.0	70.7	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Tokelau Other/Residential – Sectoral approach – liquid	N_2O	0.00	0.00	20.0	50.0	53.9	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Tokelau IPPU – Other product manufacture and use	N_2O	0.05	0.02	15.0	0.0	15.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
Tokelau Waste – wastewater treatment and discharge	N_2O	0.02	0.00	10.0	90.0	90.6	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO_2-e)	2020 emissions or absolute value of removals (kt CO_2-e)	Activity data uncertainty (%)	Emission or removal factor uncertainty (%)	Combined uncertainty (%)	Combined uncertainty as a per cent of the national total in 2020 (%)	Combined uncertainty as a per cent of the national total in the last year (%)	Type A sensitivity (%)	Type B sensitivity (%)	Uncertainty in the trend in national total introduced by emission or removal factor uncertainty (%)	Uncertainty in trend in national total introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in the national total (%)	Combined uncertainty of the national total in 1990	Combined uncertainty of the national total in the last year
Tokelau Waste – Incineration and open burning of waste	N_2O	0.01	0.01	50.0	100.0	111.8	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
2.F.1 Refrigeration and air conditioning	HFCs	0.00	1391.56	34.0	0.0	34.0	0.0	0.6	0.0213	0.0213	0.0000	1.0263	1.0263	0.00000000	0.36070136
2.F.2 Foam blowing agents	HFCs	0.00	6.23	12.0	50.0	51.4	0.0	0.0	0.0001	0.0001	0.0048	0.0016	0.0050	0.00000000	0.00001652
2.F.3 Fire protection	HFCs	0.00	2.18	10.0	41.0	42.2	0.0	0.0	0.0000	0.0000	0.0014	0.0005	0.0014	0.00000000	0.00000136
2.F.4 Aerosols	HFCs	0.00	80.09	30.0	30.0	42.4	0.0	0.0	0.0012	0.0012	0.0369	0.0521	0.0638	0.00000000	0.00186062
2.C.3.a Aluminium	PFCs	909.95	87.91	5.0	30.0	30.4	0.4	0.0	0.0155	0.0013	0.4654	0.0095	0.4655	0.18018607	0.00115179
2.F.1 Refrigeration and air conditioning	PFCs	0.00	0.00	25.0	0.0	25.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
2.G.2 Other product use	PFCs	0.00	0.01	80.0	0.0	80.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000000	0.00000000
2.C.4 Magnesium production	SF_6	2.74	0.00	100.0	0.0	100.0	0.0	0.0	0.0001	0.0000	0.0000	0.0000	0.0000	0.00001761	0.00000000
2.G.1 Electrical equipment	SF_6	14.50	13.95	20.0	30.0	36.1	0.0	0.0	0.0001	0.0002	0.0016	0.0061	0.0063	0.00006431	0.00004076
2.G.2 Other product use	SF_6	2.74	2.74	80.0	0.0	80.0	0.0	0.0	0.0000	0.0000	0.0000	0.0047	0.0047	0.00001127	0.00000772
Tokelau IPPU – Product uses as substitutes for ODS	HFCs	0.00	0.23	44.0	0.0	44.0	0.0	0.0	0.0000	0.0000	0.0000	0.0002	0.0002	0.00000000	0.00000002
Total emissions/removals		**65,196.98**	**78,778.36**			**Uncertainty in the base year**	**9.5%**		**Uncertainty in the final year**	**8.8%**			**Uncertainty in the trend**	**6.4%**	

Annex 2: References

IPCC. 2006. Eggleston HS, Buendia L, Miwa K, Ngara T, Tanabe K (eds). *2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 1. General Guidance and Reporting.* IPCC National Greenhouse Gas Inventories Programme. Japan: Published for the IPCC by the Institute for Global Environmental Strategies.

UNFCCC. 2013. FCCC/CP/2013/Add.3. *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 (addendum to Decision 24/CP.19)*.

Annex 3: Detailed methodological information for other sectors

A3.1 Supplementary information for the Agriculture sector

A3.1.1 Livestock population data

Agricultural Production Census 2017 and Agricultural Production Survey 2020

Details of the Agricultural Production census (APC) and Agricultural Production survey (APS) are included to provide an understanding of the livestock statistics process and uncertainty values. The information here is provided by Stats NZ, with full details available from the Stats NZ website (www.stats.govt.nz/information-releases/agricultural-production-statistics-june-2019-final).

Stats NZ conducts the APC every five years, with the most recent census held in 2017. In all other years, Stats NZ carries out the APS, which applies a similar method to the APC, but targets about half of the businesses involved in agriculture or forestry production. The National Inventory Report is compiled with data from the APC and APS.

The 2020 APS used a stratified sample design to select a sample from the target population (all registered businesses that were engaged in agricultural production activity (including livestock, cropping, horticulture and forestry) or that owned land intended for agricultural activity during the year ended 30 June 2020). The response rate, or the estimated proportion of eligible businesses that responded to the 2020 APS, was 82.1 per cent.

The imputation levels of the 2017 APC and 2020 APS are provided in table A3.1.1. Full details on APC and APS data collection methodology can be found on the Stats NZ website (datainfoplus.stats.govt.nz).

Sampling error arises in the APS from selecting a sample of businesses and weighting the results rather than taking a complete enumeration (i.e., census). Non-sampling error arises from biases in the patterns of response and non-response, inaccuracies in reporting by respondents and errors in the recording and classification of data. Stats NZ adopts procedures to detect and minimise these types of errors, but they may still occur and are not easy to quantify.

Table A3.1.1 Imputation levels and sampling errors for recent Agricultural Production surveys

Statistic	Proportion of total estimate imputed (%)		Relative sampling errors at 95% confidence interval (%)	
Survey year	2019	2020	2019	2020
Ewe hoggets put to ram	17	16	5	6
Breeding ewes, two tooth and over	16	17	3	3
Total number of sheep	**16**	**17**	**3**	**3**
Lambs born to ewe hoggets	16	16	5	5
Lambs born to ewes	16	17	3	3

Statistic Survey year	Proportion of total estimate imputed (%) 2019	 2020	Relative sampling errors at 95% confidence interval (%) 2019	 2020
Total number of lambs	**16**	**17**	**3**	**3**
Calves born alive to dairy heifers and/or cows	28	26	4	4
Dairy cows and heifers, in milk or calf	25	25	4	4
Total number of dairy cattle	**24**	**24**	**3**	**4**
Calves born alive to beef heifers and/or cows	18	18	4	4
Beef cows and heifers (in calf) one to two years	18	20	13	8
Beef cows and heifers (in calf) two years and over	18	18	3	4
Total number of beef cattle	**19**	**19**	**3**	**3**
Female deer mated	8	14	5	5
Total number of deer	**8**	**16**	**5**	**4**
Fawns born on farm and alive at four months	8	14	5	5
Total pigs	**3**	**5**	**1**	**1**
Area of wheat harvested	14	15	5	5
Area of barley harvested	17	14	8	8
Area of oat grain harvested	18	20	22	32
Area of maize grain harvested	15	18	10	11

Livestock characterisation in New Zealand's Tier 2 modelling

The delineation of the major livestock categories in New Zealand's Tier 2 livestock nutritional and energy requirements modelling (see table A3.1.2) are taken from population data collected by the APC and APS and Ministry for Primary Industries slaughter statistics.

Table A3.1.2 Characterisation of major livestock subcategories (dairy cattle, beef cattle, sheep and deer) in New Zealand's Tier 2 livestock modelling

Livestock category		Subcategory
Dairy cattle	Milking cows and heifers Growing females less than one year Growing females one to two years Breeding bulls	Milking cows and heifers
		Growing females less than one year
		Growing females one to two years
		Breeding bulls
	Northland Auckland Waikato Bay of Plenty Gisborne Hawke's Bay Taranaki Manawatu–Whanganui Wellington Tasman Nelson Marlborough West Coast Canterbury Otago Southland	Northland
		Auckland
		Waikato
		Bay of Plenty
		Gisborne
		Hawke's Bay
		Taranaki
		Manawatu–Whanganui
		Wellington
		Tasman
		Nelson
		Marlborough
		West Coast
		Canterbury
		Otago
		Southland

Livestock category	Subcategory
Beef cattle categories	Breeding growing cows less than one year
	Breeding growing cows one to two years
	Breeding growing cows two to three years
	Breeding mature cows
	Breeding bulls – mixed age
	Slaughter heifers less than one year
	Slaughter heifers one to two years
	Slaughter steers less than one year
	Slaughter steers one to two years
	Slaughter bulls less than one year
	Slaughter bulls one to two years
Sheep categories	Dry ewes
	Mature breeding ewes
	Growing breeding sheep
	Growing non-breeding sheep
	Wethers
	Lambs
	Rams
Deer categories	Breeding hinds
	Hinds less than one year
	Hinds one to two years
	Stags less than one year
	Stags one to two years
	Stags two to three years
	Mixed age and breeding stags

A3.1.2 Key parameters and emission factors used in the Agriculture sector

For the major livestock categories, milk yield varies over the course of a year, which affects energy requirements, feed intake and greenhouse gas emissions. Table A3.1.3 shows the proportions that are used to calculate milk yield for different months over the course of a year. Table A3.1.4 shows the emission factors used to calculate methane emissions from minor livestock species, while tables A3.1.5 and A3.1.6 show the emission factors used to calculate nitrous oxide emissions from agriculture. Table A3.1.7 shows some of the parameter values used to calculate nitrous oxide emissions.

Table A3.1.3 Proportion of annual milk yield each month for major livestock categories

Month	Dairy cattle	Beef cattle	Sheep	Deer
July	0.0088	0.0000	0.0000	0.0000
August	0.0578	0.0000	0.0000	0.0000
September	0.1213	0.1670	0.1639	0.0000
October	0.1503	0.1670	0.2541	0.0000
November	0.1425	0.1670	0.2459	0.1000
December	0.1282	0.1670	0.2541	0.2583
January	0.1109	0.1670	0.0820	0.2583
February	0.0900	0.1670	0.0000	0.2333

Month	Dairy cattle	Beef cattle	Sheep	Deer
March	0.0851	0.0000	0.0000	0.1500
April	0.0654	0.0000	0.0000	0.0000
May	0.0335	0.0000	0.0000	0.0000
June	0.0061	0.0000	0.0000	0.0000

Source: Suttie (2012) and Pickering and Fick (2015)

Note: All values presented in the table are rounded to four decimal places for presentation purposes and more precise values are available upon request.

Table A3.1.4 Methane emission factors for Tier 1 enteric fermentation livestock and manure management

Emission factor	Emission type	Source	Parameter value (kg CH_4/head/yr)
EF_{GOATS}	Enteric fermentation – goats	Lassey (2011)	9.0[1]
EF_{HORSES}	Enteric fermentation – horses	IPCC (2006a), table 10.10	18.0
EF_{MULES}	Enteric fermentation – mules and asses	IPCC (2006a), table 10.10	10.0
EF_{SWINE}	Enteric fermentation – swine	Hill (2012)	1.06
EF_{ALPACA}	Enteric fermentation – alpaca	IPCC (2006a), table 10.10	8.0
MM_{GOATS}	Manure management – goats	IPCC (2006a), table 10.15	0.20
MM_{HORSES}	Manure management – horses	IPCC (2006a), table 10.15	2.34
MM_{MULES}	Manure management – mules and asses	IPCC (2006a), table 10.15	1.1
MM_{SWINE}	Manure management – swine	Hill (2012); IPCC (2000)	5.94
$MM_{BROILERS}$	Manure management – broilers	Fick et al. (2011)	0.022
MM_{LAYERS}	Manure management – layer hens	Fick et al. (2011)	0.016
$MM_{OTHER\ POULTRY}$	Manure management – other poultry	IPCC (1996), table 4.5	0.117
MM_{ALPACA}	Manure management – alpaca	New Zealand 1990 sheep value	0.103

Table A3.1.5 Emission factors for New Zealand's agricultural nitrous oxide emissions

Emission factor	Emissions	Source	Parameter value
EF_1 (kg N_2O-N/kg N)	Direct emissions from nitrogen input to soil	Kelliher and de Klein (unpublished)	0.01
$EF_{1\text{-}UREA}$ (kg N_2O-N/kg N)	Direct emissions from nitrogen input to soil from urea fertiliser	van der Weerden et al. (2016)	0.0059
$EF_{1\text{-}DAIRY}$ (kg N_2O-N/kg N)	Direct emissions from nitrogen input to soil from dairy cattle manure	van der Weerden et al. (2016)	0.0025
EF_2 (kg N_2O-N/ha-yr)	Direct emissions from organic soil mineralisation due to cultivation	IPCC (2006a), table 11.1	8.00
EF_{3SSD} (kg N_2O-N/kg N excreted)	Direct emissions from waste in solid waste and dry lot animal waste management systems	IPCC (2000), table 4.12	0.02
$EF_{3(PRP\text{-}MINOR)}$ (kg N_2O-N/kg N excreted)	Direct emissions from manure (dung and urine) from minor grazing animals (i.e., *excluding* cattle, sheep and deer) in pasture, range and paddock systems	Carran et al. (1995); Muller et al. (1995); de Klein et al. (2003)	0.01

[1] Value is for 2020. In 1990, the value was EF 7.4 kg CH_4/head/year. Values for the intermediate years between 1990 and 2018 are calculated based on the estimated proportion of dairy goats in the overall goat population.

Emission factor	Emissions	Source	Parameter value
$EF_{3(PRP\ DUNG)}$ (kg N_2O-N/kg N excreted)	Direct emissions from dung in pasture, range and paddock systems for cattle, sheep and deer (direct emission factors for dung are reported in table A3.1.6)	van der Weerden et al. (2019)	0.0012
EF_{3OTHER} (kg N_2O-N/kg N excreted)	Direct emissions from waste in other animal waste management systems	IPCC (2000), table 4.13	0.005
$EF_{3POULTRY}$ (kg N_2O-N/kg N excreted)	Direct emissions from waste in other animal waste management systems – poultry specific	Fick et al. (2011)	0.001
EF_4 (kg N_2O-N/kg NH_x-N)	Indirect emissions from volatising nitrogen	IPCC (2006a), table 11.3	0.01
EF_5 (kg N_2O-N/kg N leached and runoff)	Indirect emissions from leaching nitrogen	IPCC (2006a), table 11.3	0.0075

Table A3.1.6 Direct nitrous oxide emission factors for urine deposited by cattle, sheep and deer, by livestock type and slope

Livestock type	Emission factor by topography (kg N_2O–N/kg N excreted)	
	Flat and low sloped land (less than 12° gradient) $EF_{3(PRP\text{-}FLAT)}$	Medium and steep sloped land (greater than 12° gradient) $EF_{3(PRP\text{-}STEEP)}$
All cattle (includes dairy and non-dairy)	0.0098	0.0033
Deer	0.0074	0.0020
Sheep	0.0050	0.0008

Source: Values used as calculated by van der Weerden et al. (2019)

Table A3.1.7 Parameter values for New Zealand's agriculture nitrous oxide emissions

Parameter (fraction)	Fraction of the parameter	Source	Parameter value
$Frac_{GASF}$ (kg NH_3-N + NO_x-N/kg of synthetic fertiliser N applied)	Total of synthetic fertiliser emitted as NO_x or NH_3	IPCC (2006a) verified by Sherlock et al. (2008)	0.1
$Frac_{GASM}$ (kg NH_3-N + NO_x-N/kg of N excreted by livestock)	Total of nitrogen emitted as NO_x or NH_3	Sherlock et al. (2008)	0.1
$Frac_{LEACH(-H)}$ (kg N/kg fertiliser or manure N)	Nitrogen input to soils that is lost through leaching and run-off	Welten et al. (2021) Thomas et al. (unpublished, 2005)	0.10 (Cropland) 0.07 (Grassland)
$Frac_{BURN}$ (kg N/kg crop-N)	Crop residue burned in fields	Thomas et al. (2008), table 14	Crop specific survey data
$Frac_{BURNL}$ (kg N/kg legume-N)	Legume crop residue burned in fields	Thomas et al. (2008) Practice does not occur in New Zealand	0
$Frac_{RENEW}$	Fraction of land undergoing pasture renewal	Thomas et al. (2014)	Year specific
$Frac_{REMOVE}$	Fraction of nitrogen in above-ground residues removed for bedding, feed or construction	Thomas et al. (2014) Practice does not occur in New Zealand	0
$Frac_{FUEL}$ (N/kg N excreted)	Livestock nitrogen excretion in excrements burned for fuel	Practice does not occur in New Zealand	0

Some of the parameters used to calculate *Nitrous oxide emissions from crop residue returned to soil* and emissions from *Field burning of agricultural residues* are summarised in table A3.1.8. These values are taken from research conducted by Thomas et al. (2008, 2011).

Table A3.1.8 Parameter values for New Zealand's cropping emissions

Crop	HI	dmf	AG_N	Root Shoot ratio R_{BG}	BG_N
Wheat	0.41	0.86	0.005	0.1	0.009
Barley	0.46	0.86	0.005	0.1	0.009
Oats	0.30	0.86	0.005	0.1	0.009
Maize grain	0.50	0.86	0.007	0.1	0.007
Field seed peas	0.50	0.21	0.02	0.1	0.015
Lentils	0.50	0.86	0.02	0.1	0.015
Peas fresh and processed	0.45	0.86	0.03	0.1	0.015
Potatoes	0.90	0.22	0.02	0.1	0.01
Onions	0.80	0.11	0.02	0.1	0.01
Sweet corn	0.55	0.24	0.009	0.1	0.007
Squash	0.80	0.20	0.02	0.1	0.01
Herbage seeds	0.11	0.85	0.015	0.1	0.01
Legume seeds	0.09	0.85	0.04	0.1	0.01
Brassica seeds	0.20	0.85	0.01	0.1	0.008

Source: Thomas et al. (2008, 2011)

Note: AG_N = above-ground nitrogen residue; BG_N = below-ground nitrogen residue; dmf = dry-matter conversion factor; HI = harvest index; R_{BG} = ratio of below-ground residues to the harvest yield.

A3.1.3 Methodology and data used to allocate livestock excreta to different hill slopes, for cattle, sheep and deer

The emission factors used to calculate direct nitrous oxide (N_2O) emissions from all cattle, sheep and deer were described in detail in chapter 5, section 5.5.2. These pages explained the research behind the revised emission factors and how they were applied to estimate emissions from cattle, sheep and deer on different hill slopes.

These revised emission factors are disaggregated by slope (as well as livestock type), and a methodology is used to calculate the amount of nitrogen (in the form of urine or dung) deposited on these different slopes. The steps described below are used to do this.

The nutrient transfer model outlined by Saggar et al. (2015) is used to allocate total dung and urine (calculated elsewhere in the inventory model) between low, medium and steep slopes. The nutrient transfer model was discussed by the Agriculture Inventory Advisory Panel in 2015, which agreed that the methodology used in the nutrient transfer model was appropriate. Beef + Lamb New Zealand Ltd provides data (on the topography and number of animals on different farm types) used in the nutrient transfer model.

Dairy excreta is not allocated to different slope types because the Inventory assumes that all dairy cattle graze on flatland. The flatland/low slope emission factor for cattle urine ($EF_{3(PRP\ FLAT)}$ = 0.0098) is applied to all dairy cattle urine.

Step 1: Calculations of total nitrogen excretion rates for each animal category

Total nitrogen excretion rates (N_{ex}) for each animal category are calculated using the methods described in chapter 5, section 5.3.2 of the National Inventory Report (*Nitrogen excretion rates for the major livestock categories*), and in chapter 5 of Pickering et al. (2020).

Step 2: Split of nitrogen between urine and dung

The total N_{ex} calculated in step 1 is split into urine and dung using the method described by Pacheco et al. (unpublished), and section 5.2.4 (beef cattle), section 5.3.5 (sheep) and section 5.4.5 (deer) of Pickering and Gibbs (2019).

Step 3: Allocating urine excreta to different hill slopes

The nutrient transfer model (described by Saggar et al. (2015)) uses Beef + Lamb New Zealand Ltd data on the proportion of sheep and beef farmland on different hill slopes to allocate urine excreta to different hill slopes. The nutrient transfer model takes into account the preference for animals to spend more time on flatter slopes. Using this model, the proportion of excreta deposited on low slopes is greater than the proportion of low slope land area, because animals spend more time on flatter land.

The equations and variables needed to allocate excreta to different slopes are outlined in table A3.1.9 and figures A3.1.1 and A3.1.2. For example, an area with 60 per cent low slopes and 25 per cent steep slopes will have 72 per cent of livestock urine deposited on low slope land (0.45*60 per cent + 0.45 = 72 per cent) and 14 per cent of livestock urine deposited on steep slope land. After the allocation of excreta to low and high slope areas, the remainder (14 per cent) is assumed to be deposited onto medium sloped land.

Because a single dung emission factor ($EF_{3(PRP\text{-}DUNG)}$ = 0.0012) is used across all slope categories for cattle, sheep and deer, dung excreta does not need to be allocated to different slopes.

Table A3.1.9 Allocation of urine deposition to low slope (0–12 degrees) and steep slope (more than 24 degrees), split by the percentage of low slope and steep slope land available

Allocation to flat land	
Percentage of low land area	**Fraction urine deposition**
Less than 1%	27x
1–5%	0.27
5–9%	0.405
9–35%	0.55
35–85%	(0.45x + 0.45)
Greater than 85%	(0.5x + 0.5)
Allocation to steep land	
Percentage of steep land area	**Fraction urine deposition**
Less than 1%	10x
1–20%	0.10
20–40%	0.14
40–60%	0.21
60–85%	0.28
Greater than 85%	4.8x – 3.8

Figure A3.1.1 **Proportion of urine nitrogen (N) applied to low (0–12 degree) slopes using a nutrient transfer model (equal proportion line shown in grey for comparison)**

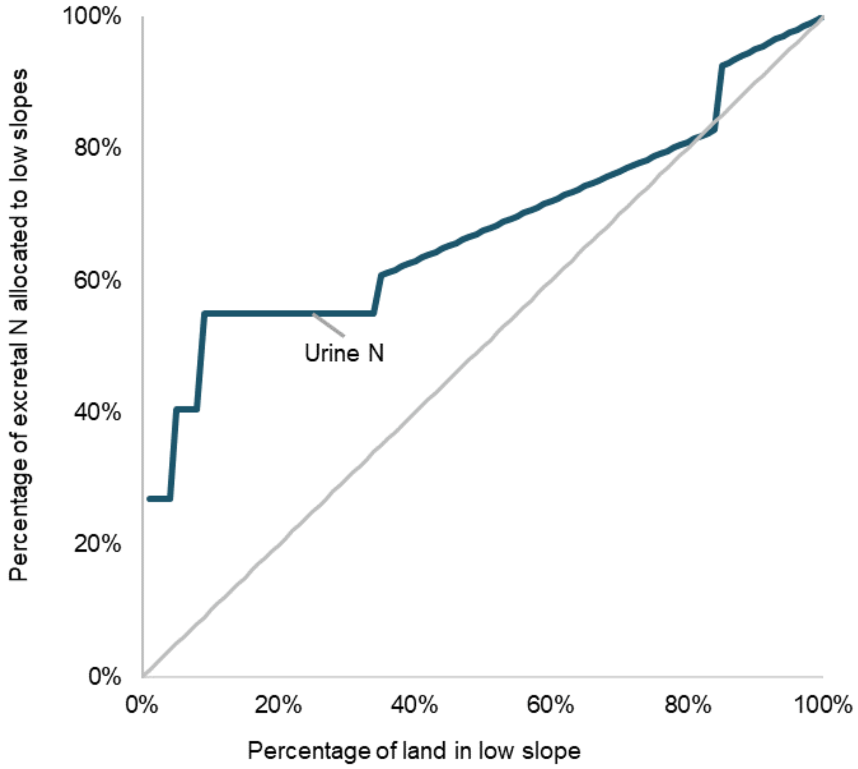
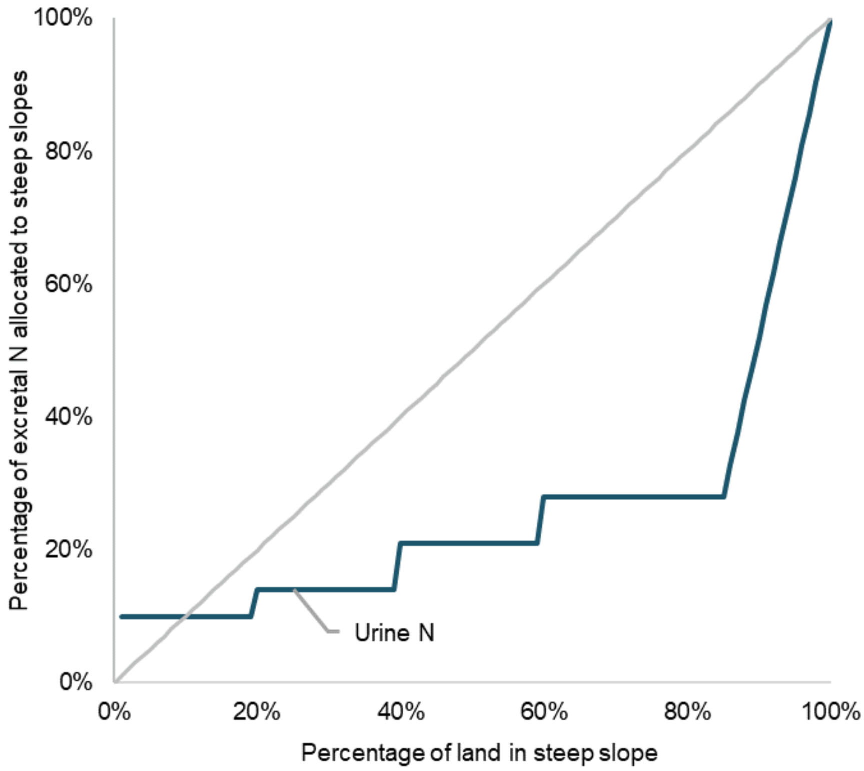


Figure A3.1.2 **Proportion of urine nitrogen (N) applied to steep (more than 24 degree) slopes using a nutrient transfer model (equal proportion line shown in grey for comparison)**



Tables A3.1.10, A3.1.11, A3.1.12 and figure A3.1.3 provide examples of how this nutrient allocation methodology uses Beef + Lamb New Zealand Ltd data to allocate urine nitrogen (N) to different hill slopes. First, data on the number of sheep, beef cattle and deer in each farm class are used to allocate total urine N (calculated using the methods described in chapter 5, section 5.3.2 of the National Inventory Report) to these different farm classes (tables A3.1.11 and A3.1.12).

Table A3.1.10 Share of livestock population, and amount of urine nitrogen (N) deposition in 2020, by Beef + Lamb New Zealand Ltd farm class

Farm class	Percentage of sheep population on farm class (%)	Amount of sheep urine N on farm class (kg N)	Percentage of beef cattle population on farm class (%)	Amount of beef cattle urine N on farm class (kg N)	Percentage of deer population on farm class (%)	Amount of deer urine N on farm class (kg N)
1. South Island High Country	7.5	26,142,209	3.8	8,979,410	14.1	2,818,498
2. South Island Hill Country	11.8	40,781,153	6.5	15,348,031	7.7	1,536,708
3. North Island Hard Hill Country	16.7	57,962,517	15.1	35,592,510	6.1	1,219,923
4. North Island Hill Country	25.9	89,648,756	40.6	95,775,767	35.5	7,088,432
5. North Island Intensive Finishing	5.8	20,214,694	11.6	27,278,373	0.5	101,476
6. South Island Finishing Breeding	19.7	68,118,956	14.8	34,805,231	28.2	5,628,649
7. South Island Intensive Finishing	10.3	35,845,952	3.5	8,269,167	8.0	1,591,047
8. South Island Mixed Finishing	2.3	7,936,520	4.1	9,692,090	0.0	0
Total		**346,650,757**		**235,740,580**		**19,984,733**

Each farm class has a different proportion of land in low, medium and steep slopes, as shown in table A3.1.11. These data are combined with the nutrient transfer methodology to calculate total urine N that is estimated to be deposited on different hill slopes for different animal categories. From this point, direct N_2O emissions can be calculated using the emission factors in chapter 5, table 5.5.3.

Table A3.1.11 Proportion of total sheep, beef and deer land on different hill slopes, by Beef + Lamb New Zealand Ltd farm class, for 2019/20

Farm class	Land type by slope		
	Flat/low (0–12° slope) (%)	Rolling/medium (12–24° slope) (%)	Steep (>24° slope) (%)
1. South Island High Country	7.9	27.2	64.9
2. South Island Hill Country	17.1	24.6	58.3
3. North Island Hard Hill Country	8.4	33.7	57.9
4. North Island Hill Country	16.5	54.4	29.1
5. North Island Intensive Finishing	43.0	51.9	5.1
6. South Island Finishing Breeding	35.0	48.2	16.7
7. South Island Intensive Finishing	58.9	41.1	0.0
8. South Island Mixed Finishing	89.4	10.6	0.0
Total sheep, beef and deer land	**21.1**	**38.3**	**40.6**

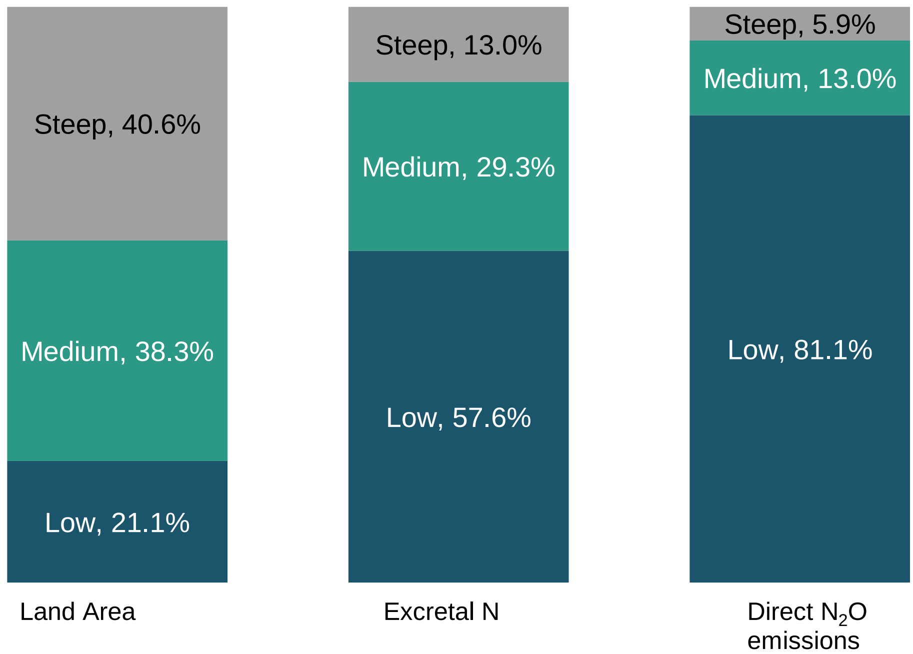
Note: The percentages may not add up to 100 per cent due to rounding.

Table A3.1.12 Proportion of total sheep, beef and deer urine nitrogen deposited on different hill slopes, by Beef + Lamb New Zealand Ltd farm class, for 2020

Farm class	Flat/low	Rolling/medium	Steep
1. South Island High Country	0.41	0.32	0.28
2. South Island Hill Country	0.55	0.24	0.21
3. North Island Hard Hill Country	0.41	0.39	0.21
4. North Island Hill Country	0.55	0.31	0.14
5. North Island Intensive Finishing	0.64	0.26	0.10
6. South Island Finishing Breeding	0.61	0.29	0.10
7. South Island Intensive Finishing	0.72	0.28	0.00
8. South Island Mixed Finishing	0.95	0.05	0.00
Total sheep urine	**0.56**	**0.30**	**0.14**
Total beef urine	**0.56**	**0.30**	**0.14**
Total deer urine	**0.55**	**0.30**	**0.15**
Total sheep, beef and deer urine	**0.56**	**0.30**	**0.14**

Note: The proportions may not add up to 1 due to rounding.

Figure A3.1.3 Proportion of land area, excretal nitrogen (N) and nitrous oxide (N_2O) emissions by hill slope category for sheep, beef cattle and deer farms in 2020



A3.2 Supplementary information for the LULUCF sector

A3.2.1 Land use mapping methodology

Areas of land use and land-use change between 1990 and 2020 are based on four wall-to-wall land use maps derived from satellite imagery at nominal mapping dates of 31 December 1989, 31 December 2007, 31 December 2012 and 31 December 2016. Area information from these maps is interpolated and extrapolated to obtain a complete time series of land-use change occurring between 1990 and 2020.

Satellite image acquisition and pre-processing

Each of the national land use maps is based on a collection of either Landsat, SPOT[2] or Sentinel-2 satellite imagery acquired over the summer periods (October to March) as described in table A3.2.1. Acquisition is limited to the summer months, because a high sun angle is required to reduce shadowing and increase the dynamic range of the signal received from the ground.

Table A3.2.1 Satellite imagery used for land use mapping in 1990, 2008, 2012 and 2016

Land use map	Satellite imagery	Resolution (metres)	Acquisition period
1990	Landsat 4 and Landsat 5	30	November 1988 – February 1993
2008	SPOT 5	10	November 2006 – April 2008
2012	SPOT 5	10	October 2011 – March 2013
2016	Sentinel-2	10	October 2016 – March 2017

All the imagery was orthorectified and atmospherically corrected and then standardised for spectral reflectance using the Ecosat algorithms documented in Dymond et al. (2001), Shepherd and Dymond (2003) and Dymond and Shepherd (2004). This standardisation process removes the effect of terrain slope from the imagery, effectively 'flattening' it, so that individual land cover types are a more consistent colour across the whole image. By minimising the effects of terrain, a more accurate and consistent classification of land use is possible. This is particularly important in New Zealand, due to the extensive areas of steep terrain.

The final step in image preparation was the mosaicking of the satellite image scenes into a seamless national image. To minimise the effect of cloud and cloud shadows in the mosaic, cloud masks were generated for each scene. These masks were then used to prioritise the order of inclusion of each scene in the mosaic to obtain a near cloud-free image of New Zealand at each mapping date.

Creating the first two land use maps: 1990 and 2008

Mapping approach

The 1990 and 2008 land use maps were created using a common mapping approach based on difference detection from an intermediate reference land-cover layer that was derived from Landsat 7 ETM+ imagery acquired in 2000 and 2001. A semi-automated approach was used to classify woody land cover[3] in the 1990 and 2008 image mosaics. These layers were then differenced from the 2001 reference layer to create a 1990 to 2001 potential woody change layer and a 2001 to 2008 potential woody change layer.

The potential woody change layers were visually checked to confirm change and then the changes were combined with the 2001 reference layer to create the 1990 and 2008 woody land cover layers. By using this approach, it was possible to obtain a consistent resolution of change detection even though there was a significant difference between the resolutions of the source imagery at the two mapping dates: 30 metres at 1990 versus 10 metres at 2008.

Area and proximity rules were used to convert these layers from woody land cover to woody land use, making allowances for unstocked areas within forest extents and areas of regenerating vegetation in a forest context. This process is described in Shepherd and Newsome (unpublished(b)).

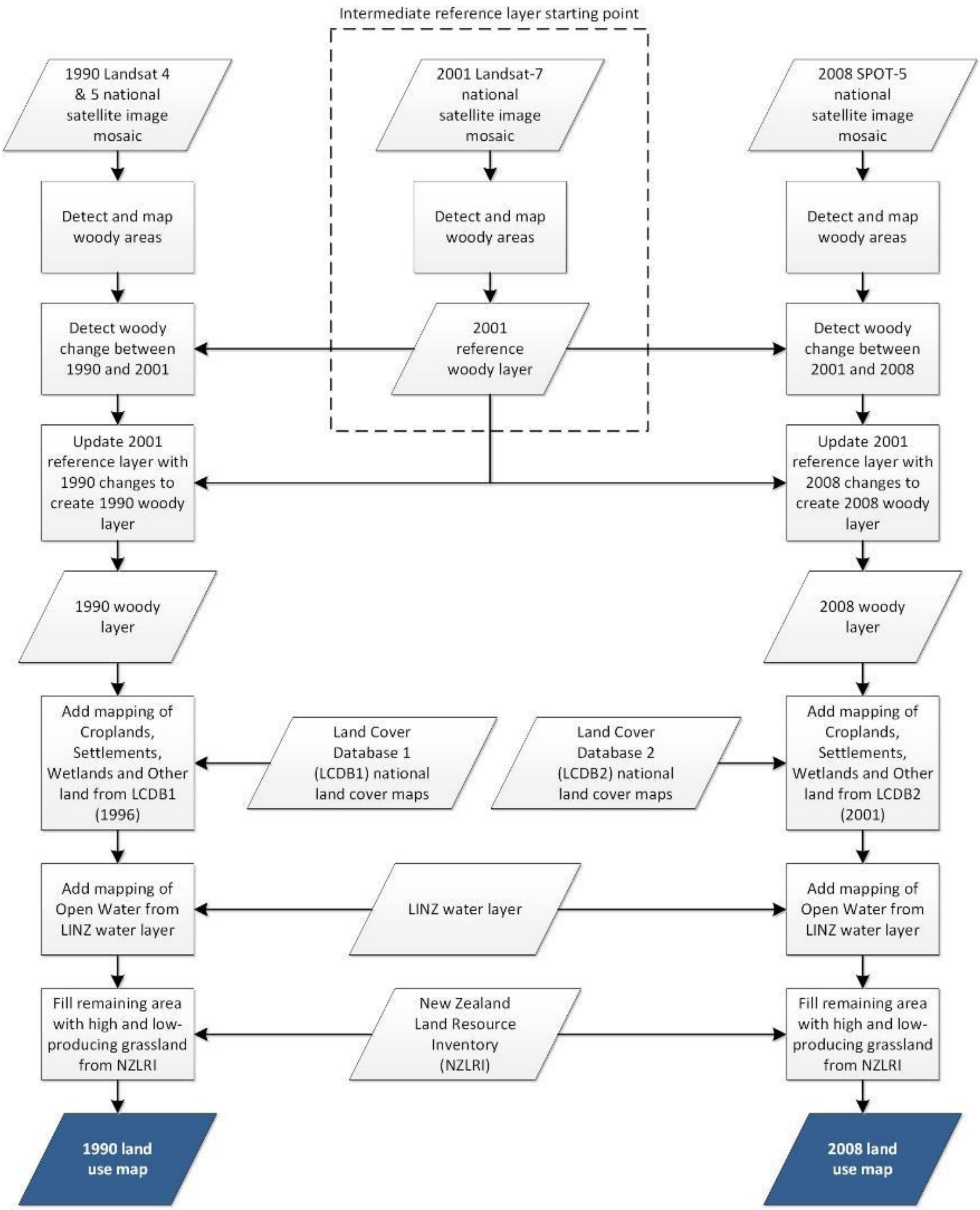
2 From French 'Satellite pour l'Observation de la Terre'.

3 Land cover consistent with pre-1990 natural forest, pre-1990 planted forest, post-1989 forest and grassland with woody biomass land uses.

To determine the spatial location of the other land uses as at 1990 and 2008, information from two Land Cover Databases, LCDB1 (1996) and LCDB2 (2001) (Thompson et al., 2004), hydrological data from Land Information New Zealand (a government agency) and the New Zealand Land Resource Inventory (NZLRI) (Eyles, 1977) were used (Shepherd and Newsome, unpublished(a)).

The NZLRI database defined the area of high and low producing grassland. Areas tagged as 'improved pasture' in the NZLRI vegetation records were classified as high producing grassland in the land use maps. All other areas were classified as low producing grassland. Figure A3.2.1 illustrates this mapping process.

Figure A3.2.1 New Zealand's land use mapping process for 1990 and 2008 land use maps



Note: LINZ = Toitū Te Whenua Land Information New Zealand.

An interpretation guide for automated and visual interpretation of satellite imagery was prepared and used to ensure a consistent basis for all mapping processes (Ministry for the Environment, 2012). During the mapping process, independent quality control checks were performed to ensure consistent image interpretation. This involved an independent agency looking at randomly selected points across New Zealand and using the same data as the original operator to decide within what land use the point fell. The two operators were in agreement at least 95 per cent of the time. This is described in more detail in Joyce (unpublished).

Decision process for mapping post-1989 forests

The use of remotely sensed imagery has some limitations, in particular, a limited ability to map planted forest of less than three years of age. Where trees are planted within three years of the image acquisition date, they (and their surrounding vegetation) are unlikely to show a distinguishable spectral signature in satellite imagery. This occurs particularly with coarse-resolution (30 metres) Landsat 4 and 5 imagery captured around 1990. This situation is compounded by the lack of ancillary data at 1990 to support land use classification decisions. However, since 2009, the New Zealand Emissions Trading Scheme (NZ ETS) has provided valuable spatial information that has been used to confirm 1990 forest land use classifications.

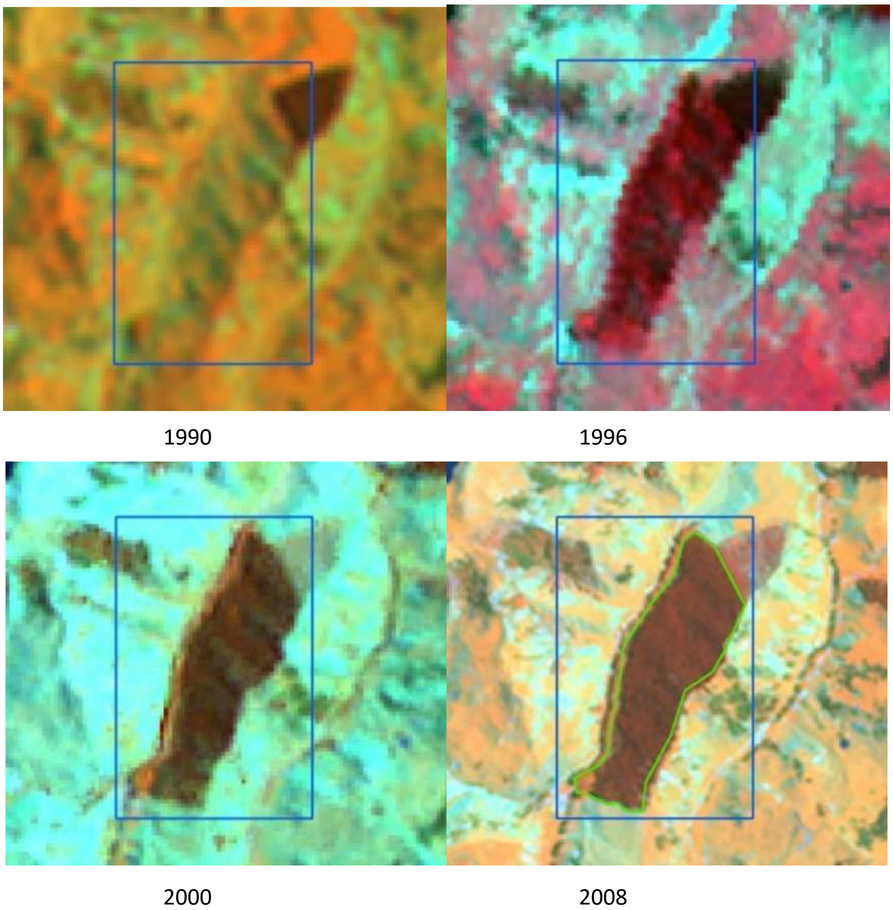
Owners of post-1989 forest may apply to lodge their forests within the NZ ETS to obtain credit for increases in carbon stock since 1 January 2008. Mapping received by Te Uru Rākau – Ministry for Primary Industries for these applications is used to improve the Land Use and Carbon Analysis System (LUCAS) land use maps.

Mapping from the NZ ETS (and other post-1989 forestry schemes) has also provided a significant source of planting date information, which helps determine the correct classification of planted forest. The Forestry Allocation Plan, which forms part of the NZ ETS, compensates private owners of pre-1990 planted forest for the loss in land value arising from the introduction of penalties for deforesting pre-1990 forest land. Forest owners must apply for this compensation, providing detailed mapping and evidence of their forest planting date. These mapping data are used regularly to improve the classification accuracy of the LUCAS land use maps.

To help the decision-making process, nationwide cloud-free 1996 SPOT and 2001 Landsat 7 satellite image mosaics are also used to determine the age of forests that have been planted within two to three years of 1990. Figure A3.2.2 shows how mapping operators use the spectral signature in later imagery and ancillary information to determine the status of an area of planted forest established around 1990.

Where possible, information obtained directly from forest owners and the national planted forest plot network is also used to improve the accuracy of the pre-1990 and post-1989 forest classification.

Figure A3.2.2 Identification of post-1989 forest in New Zealand

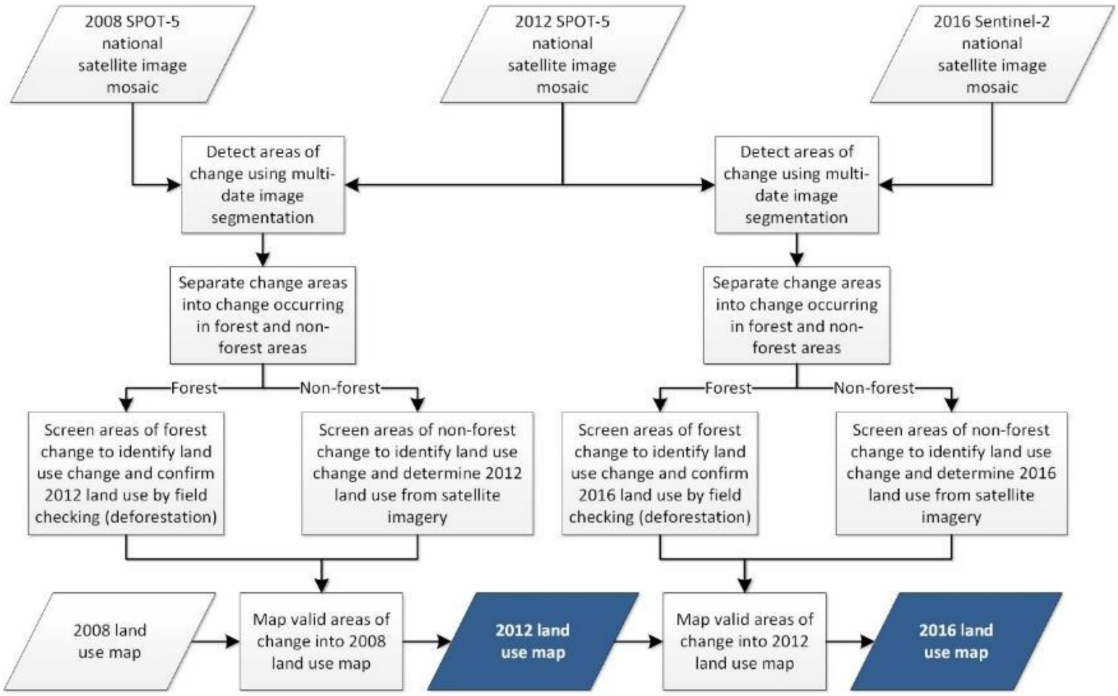


Images:	1990 Landsat 4 (top left) 1996 SPOT 2 (top right) 2000 Landsat 7 ETM+ (bottom left) 2008 SPOT 5 (bottom right)
Location:	2,017,800, 5,730,677 (NZTM)
1990 land use:	Low producing grassland
2008 land use:	Post-1989 forest
Explanation:	In the Landsat 1990 imagery acquired on 2 December 1990, there is little evidence of the forest within the blue box that is clearly apparent in later imagery. The strength of the spectral response in the SPOT 1996 imagery suggests that the forest must have been planted near to 1990. Final confirmation of the planting date is provided via the NZ ETS application (delineated in green in the 2008 imagery), which states that the forest was planted in 1990 and, therefore, is classed as a post-1989 forest.

Adding land use maps to the time series: 2012 and 2016 land use maps

The 2012 and 2016 land use maps were created by detecting change between satellite imagery acquired for each mapping year (2008, 2012 and 2016) (Newsome et al., 2013; 2018). The 2012 map was created by using the 2008 map as a starting point and mapping in all the change detected between 2008 and 2012. Similarly, the 2012 map was used as a starting point for the 2016 map, with all areas of change detected between 2012 and 2016 mapped in to the 2012 map to create a snapshot of land use as at 2016. Figure A3.2.3 illustrates this mapping process.

Figure A3.2.3 New Zealand's land use mapping process for 2012 and 2016 land use maps



A multi-date image segmentation process was used to identify areas of potential change. This process is described in Shepherd et al. (2019). These areas of potential change were confirmed using two separate approaches: one for areas mapped as non-forest at the start of the period and one for areas mapped as forest at the start of the period. These approaches are discussed further in the subsequent sections.

Mapping approach: non-forest areas

Potential changes in areas mapped as non-forest were manually checked in the satellite imagery to determine whether a land-use change had occurred since the previous land use map. Operators used the 2008 and 2012 SPOT imagery and 2016 Sentinel-2 imagery, along with other imagery data sets as listed in table A3.2.2, to establish whether land-use change had occurred. Once change was confirmed, the area of change was delineated in the land use map.

Table A3.2.2 Ancillary mosaicked imagery data sets used in land use mapping

Satellite imagery	Resolution (m)	Coverage	Acquisition period
Landsat 7	30	North Island, South Island and Stewart Island	September 1999 – February 2003 October 2011 – February 2012 October 2012 – March 2013
SPOT maps products	2.5 and 1.5	North Island, South Island and Stewart Island	January 2008 – June 2009 October 2012 – April 2014
Disaster Monitoring Constellation	22	North Island, South Island and Stewart Island	November 2009 – March 2010
SPOT 5	10	Four priority areas: Northland, Waikato, Marlborough and Southland	October 2010 – March 2011
Landsat 8	30	North Island, South Island and Stewart Island	November 2013 – February 2014 October 2014 – March 2015 October 2015 – March 2016
Sentinel-2	10	North Island, South Island and Stewart Island	November 2015 – March 2016
Aerial photography	Variable	All of North Island and Stewart Island and most of South Island	Various

As part of the 2016 mapping process, high and low producing grassland classes were mapped at 2008, 2012 and 2016 using a data fusion technique described in Manderson et al. (2018). This technique brought together a range of biophysical and land use data sets to create a probability map for high producing grassland at each mapping date. This map was used to classify grassland into high and low producing areas in the 2016 land use map and back-correct the 2012 and 2008 maps to maintain time-series consistency. Before the 2016 map, grassland areas had been split into high-producing and low-producing based on the mapping of high-producing grassland in the NZLRI, which was completed in the mid-1980s. No changes between grassland subcategories had been mapped throughout the time series, and any change to grassland from other land uses were classified into low or high producing grassland based on imagery and context. The 1990 land use map was assumed to contain a fair representation of the split between high and low producing grassland, based on the original mapping of this data set using the NZLRI as described above.

Mapping approach: forest areas

Areas of potential change within the forest extent were considered to be potential destocking.[4] These areas were first screened, to ensure they represented actual change, as opposed to false change related to cloud contamination or image misregistration.

The next step was to determine which areas of destocking represented land-use change (deforestation) as opposed to temporary forest loss (e.g., harvesting activity occurring as part of ongoing forestry land use).

Where possible, areas of destocking were first checked in pre-existing aerial orthophotography to determine whether replanting may have occurred. Cases of replanting were then classified as ‘harvested’ and excluded from further consideration.

Because it is rarely possible to determine whether deforestation has occurred using currently available satellite imagery alone, high-resolution vertical or oblique aerial photography is necessary to provide a detailed view of land use activity occurring subsequently on the ground.

All remaining unclassified areas of destocking were field checked by obtaining aerial photography over each site.

Based on the aerial photographic evidence and supplemental deforestation data from the NZ ETS, each area was given one of the following destock classifications.

- Harvested: the area shows evidence of ongoing forestry land use such as replanting, preparation for planting or a context consistent with replanting, such as being surrounded by plantation forestry.
- Harvested and converted: the forest stand is registered in the NZ ETS using the Carbon Equivalent Forest option to harvest, but replanted in a different location.
- Deforested: the area shows evidence of land-use change, such as the removal of stumps, pasture establishment, fencing and stock, or earthworks.
- Awaiting: the area has been destocked for less than four years[5] and/or there is no clear evidence of land-use change or replanting. That is, the area is lying fallow or, in the case of natural forest areas, the vegetation has been sprayed but not cleared.[6]

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4 ‘Destocking’ is defined here as forest loss for any reason including harvesting, deforestation or some type of non-anthropogenic change, such as wind damage or erosion.

- No change: the area has not been sufficiently destocked and was incorrectly identified as meaningful change (may include thinning activity).
- Never forest: the area in fact did not meet the forest definition at the beginning of the change period. These areas required correction to a non-forest land use in the land use map from the beginning of the change period.
- Non-anthropogenic change: destocking was not directly human induced – for example, erosion – and there has been no land-use change.

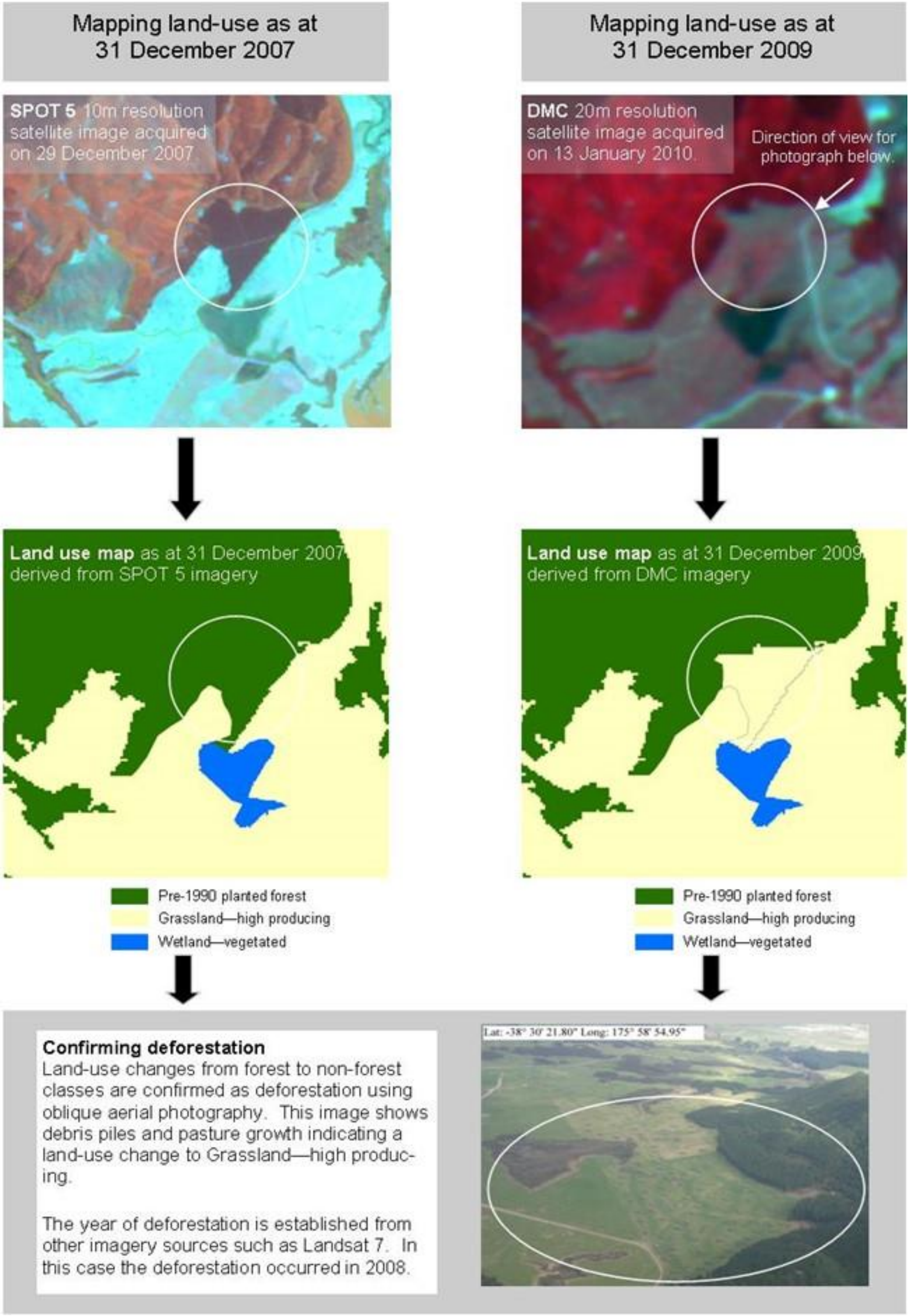
For each deforested area, further information was then recorded, such as the year in which the deforestation occurred. This was determined by examining the ancillary imagery data sets listed in table A3.2.2. Figure A3.2.4 shows the process of confirming deforestation and establishing the year in which it occurred. Further information on the mapping of forest change can be found in Indufor Asia Pacific (2018).

The final step in the 2012 and 2016 land use mapping process was to add the confirmed areas of deforestation into the land use map.

[5] To distinguish between deforestation and temporary tree crown cover removal in forest land, New Zealand has defined the expected period between the removal of tree cover and successful natural regeneration or planting as four years.

[6] Often regenerating shrubland areas are sprayed but land use conversion is not completed by clearing the area. In these instances, the vegetation regenerates and recovers, therefore, land-use change has not occurred.

Figure A3.2.4 New Zealand's identification of deforestation



Note: DMC = Disaster Monitoring Constellation.

Quality assurance/quality control (QA/QC) and verification

During the mapping process, the 1990, 2008, 2012 and 2016 land use maps were checked to determine that the mapping was consistent with the satellite image classification specification set out in *Land Use and Carbon Analysis System: Satellite imagery interpretation guide for land use classes* (Ministry for the Environment, 2012).

The quality-control checks performed on the 1990 and 2008 land use maps included checking around 28,000 randomly selected points in areas mapped as forest and grassland with woody biomass. These were evaluated by independent assessors. In this exercise, independent assessors agreed with the original classification 91 per cent of the time. Where there was disagreement, the points were recorded in a register and this was used to plan improvements to the 1990 and 2008 land use maps. These improvements were subsequently completed.

Two distinct quality-control checks were performed on the 2012 land use map. The first of these checked every polygon where land-use change had occurred from a non-forest land use between 2008 and 2012. The acceptance criterion for this check was that the land use classification had to be correct at both mapping dates at least 90 per cent of the time. This means that the land use, both at the start of the land-use change event and at the end of the land-use change event, had to be correct. The second quality-control measure was to check the accuracy of destock detection in areas that were in a forest land use at 2008. Sampling for this check was designed to test that at least 90 per cent of the destocking had been detected at the 95 per cent confidence level. Checks were completed on each of the 16 regions of New Zealand individually and all regions passed. During this process, 14,443 points were checked.

Quality-control checking for the 2016 land use map was carried out region-by-region looking at all areas of expected change (based on mapping targets sent to the mapping supplier) and actual change supplied in the map. Checks were also made for invalid change, for example, a pre-1990 planted forest cannot change to a post-1989 forest. Spatial checks were performed to ensure that the integrity of the map had been maintained. These included checking for gaps and overlaps as well as that the total area of the map had not changed.

Each mapping improvement activity carried out on the 1990, 2008, 2012 and 2016 maps has been subjected to quality-assurance checks, to ensure accuracy and consistency. Quality-assurance strategies have been tailored to each improvement activity, usually including a combination of random sampling of updated areas and analysis of the changes in land use areas.

The approach used to implement quality-assurance processes is documented in the LUCAS Data Quality Framework (PricewaterhouseCoopers, unpublished).

Uncertainties and time-series consistency

In 2014, an accuracy assessment was completed for the 2012 land use map. A stratified random sample of 2,000 points was made, and the land use classification was independently assessed at each point location. SPOT-6 natural colour 1.5-metre resolution imagery was used as the reference data source. This imagery met the criteria for a reference data source, having better resolution than the SPOT-5 10-metre resolution imagery used to create the 2012 land use map, and being acquired over a similar period.[7]

[7] The SPOT-6 natural colour 1.5-metre resolution imagery was acquired in the summers of 2012/13 and 2013/14 making it generally one year later than the SPOT-5 multi-spectral 10-metre resolution imagery used to create the 2012 land use map.

The overall map accuracy was found to be 95.2 per cent (Poyry Management Consulting (NZ) Ltd, unpublished). The user and producer accuracies for the three forest classes were all over 94 per cent. For all forest classes, the total mapped area fell within the 95 per cent confidence interval of the total class area as determined by the accuracy assessment.

Non-forest land uses generally had user and producer accuracies of over 90 per cent. Exceptions were the *Wetlands* and *Grassland with woody biomass* categories, for which producer accuracies were 85 per cent and 60 per cent respectively (Poyry Management Consulting (NZ) Ltd, unpublished). The *Wetlands* category was slightly under-mapped. This is because vegetated wetland and *Grassland with woody biomass* are sometimes difficult to distinguish in imagery where the extent of flooding varies seasonally. *Grassland with woody biomass* appears to be more substantially under-mapped, with accuracy assessment operators identifying areas of high and low producing grassland that should have been mapped as *Grassland with woody biomass*. This is also a difficult judgement call, because the boundary between areas of low producing and high producing grassland and *Grassland with woody* biomass can be hard to define and can shift with grazing.

A3.2.2 Annual land-use change

Annual land-use change areas are interpolated and extrapolated from the four national land use maps using a number of supporting data sets to inform the trends occurring between the wall-to-wall mapping dates of 1990, 2008, 2012 and 2016.

Land-use change before 1990

Data from a variety of sources were used to determine land areas before 1990. Data sources suitable for determining land use at a national level typically comprise one of the following:

- maps or scaled images depicting land use or proxies for land use (e.g., a ‘map of forest areas’)
- tabulated land use area data collected for an administrative area (e.g., county, district or region)
- production sector (e.g., the area of orchard crops).

This methodology was peer reviewed by Hunter and McNeill (unpublished), who provided independent subject-matter expertise. They noted that the methodology was sound, and the choice of historical data sets was reasonable. They judged that the method reasonably met the standards of the IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006a).

Annual land-use changes from 1990 to 2007

Annual land-use changes from 1990 to 2007 are interpolated between the 1990 and 2008 land use maps, which provide the total area of change over that period. Most of the land-use changes are interpolated linearly between mapping dates; however, some of the land-use changes make use of surrogate data sets to better reflect land-use change trends within this period. This approach follows methodology outlined in section 3.3.1 of the 2006 IPCC Guidelines (IPCC, 2006a).

The surrogate data sets used between 1 January 1990 and 31 December 2007 are as follows.

- Deforestation trends between 1990 and 1 January 2008 for pre-1990 planted forest and post-1989 forest are based on the 2008 Deforestation Intentions Survey (Manley, 2009) and unpublished work by Scion (the New Zealand Forest Research Institute). The work by Scion is referred to in Wakelin (unpublished(c))
- Afforestation trends for post-1989 planted forest are based on estimates from the National Exotic Forest Description (NEFD) (Ministry for Primary Industries, 2020)
- Afforestation trends for post-1989 natural forest are based on the plot analysis in Paul et al. (unpublished(b)). The age of vegetation on plots was used to estimate the year afforestation occurred. Afforestation area was then assigned annually by taking the number of new post-1989 natural forest plots per year (estimated using a five-year rolling average) as a proportion of the total number of post-1989 natural forest plots in 2007 and multiplying by the mapped area of post-1989 natural forest in 2007.

Annual land-use changes from 2008 to 2016

Annual land-use changes from 2008 to 2016 are generally linearly interpolated between the 2008, 2012 and 2016 land use maps. The only exceptions to this are:

- deforestation occurring between 2008 and 2016, which is mapped
- afforestation, which uses a mixture of mapped and surveyed data as detailed in table A3.2.3. This is because not all new planting will have been detected in satellite imagery and mapped into the 2016 map yet. New planting can take up to four years to be visible in satellite imagery, therefore, afforestation mapping up to 2016 will not be finalised until 2020.

Table A3.2.3 Methods used to estimate Afforestation total area and trends between 2008 and 2016

	Reporting years: 2008 to 2012		Reporting years: 2013 to 2016	
Afforestation type	Estimate of total afforestation for the period	Trend in afforestation within the period	Estimate of total afforestation for the period	Trend in afforestation within the period
Post-1989 planted forest	Based on afforestation mapped between 2008 and 2012	Based on new planting data from national survey (National Exotic Forest Description)	Based on afforestation mapped between 2013 and 2016	Based on new planting data from national survey (National Exotic Forest Description)
Post-1989 natural forest	Based on afforestation mapped between 2008 and 2012	Linear interpolation	Based on afforestation mapped between 2013 and 2016	Linear interpolation

Estimating land-use change for 2017 to 2020

Activity data for the four most recent years of this inventory from 2017 to 2020, have been estimated mainly from surveys for deforestation (Manley, 2019; Manley, 2021) and afforestation (Ministry for Primary Industries, 2020) and extrapolated from the most recent mapped period of 2012 to 2016 for all other land-use changes.

Deforestation

The area of deforestation of pre-1990 planted forest and post-1989 planted forest occurring during 2017 has been estimated based on provisional deforestation mapping for that year. Estimates for 2018 and 2019 have been based on the Deforestation Intentions Survey for 2018 (Manley, 2019). The estimate for 2020 has been based on the Afforestation and Deforestation

Intentions Survey 2020 (Manley, 2021). These reports do not distinguish between pre-1990 and post-1989 forest deforestation, therefore, the proportion of deforestation from each forest type has been estimated based on the relative proportions of deforestation of these forest types in the most recently mapped four-year period (2014–17). This ratio provides the most up-to-date estimate of the ratio of deforestation of these forest types.

Deforestation of pre-1990 (tall), pre-1990 (regenerating) and post-1989 natural forest for 2017 to 2020 has been estimated as occurring at the same annual rate as the most recently mapped three-year period (2014–16). Provisional mapping of 2017 natural forest deforestation was not used in this submission because the area mapped was less than the estimate based on the three-year average (2014–16). The confirmed mapped area for 2017 and 2018 deforestation will be included in the 2023 submission.

The destination land use for areas of estimated deforestation has been pro-rated based on the mapped destination land uses of deforestation occurring in the period 2012 to 2016. Only the major destination land uses were included in this pro-rating process. Major destination land uses were considered to be those that were consistently reported for each year across the whole mapped period for all types of forest loss. This reduced the destination land uses from 12 to 5 classes: *High-producing grasslands*, *Low-producing grasslands*, *Grassland with woody biomass*, *Settlements* and *Other land*.

Afforestation

The annual area of afforestation of post-1989 planted forest for 2017 to 2020 is based on estimates from the NEFD (Ministry for Primary Industries, 2020). The annual area of afforestation of post-1989 natural forest for 2017 to 2019 is estimated from the Ministry for Primary Industries afforestation scheme data. The area of post-1989 natural afforestation for 2020 is estimated from the Afforestation and Deforestation Intentions Survey for 2020 by taking the total area of 'natural reversion' and 'indigenous tall planted' (Manley, 2021). For post-1989 natural forest dominated by wilding exotic conifers, a linear extrapolation of the mapped area of land use change between 2012 and 2016 (for this forest type) was used to estimate afforestation for 2017 to 2020.

The land use before afforestation has been pro-rated across all non-forest land uses in the same proportions as for post-1989 afforestation that has been mapped between 2012 and 2016.

Other land-use changes

All other land-use changes for 2017 to 2020 have been linearly extrapolated from the changes mapped between 2012 and 2016.

Uncertainties and time-series consistency

Time-series consistency is maintained by using a combination of linear interpolation and extrapolation between mapping dates, and from the last mapping date, as described in section 5.3 of volume 1 of the 2006 IPCC General Guidance and Reporting (IPCC, 2006b).

It is difficult to quantify the uncertainty introduced by the interpolation and extrapolation process. The error introduced by extrapolation from the last mapping date depends on how consistent the rate of change in land use is between the mapped period, which is used to establish the trend, and the extrapolated period.

When New Zealand introduced the 2016 land use map into the reporting cycle for the Inventory submitted in 2019, replacing 2013 to 2016 extrapolated activity data with interpolated data with a mapped end point at 2016, an emission reduction of 9 per cent was reported as the recalculation for 2016. This recalculation also included other updates, however, it is not substantially different to the recalculations reported in other years, indicating that the error introduced by extrapolation is unlikely to be large.

A3.2.3 Annual land-use change summary

This section contains a summary of the annual land-use change from 1990 to 2020 (see table A3.2.4).

Table A3.2.4 Annual land-use changes (units in 000s hectares)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
From Pre – 1990 natural forest, to…																
Pre-1990 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 planted forest	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Post-1989 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – annual	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cropland – perennial	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – high producing	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Grassland – low producing	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Grassland – with woody biomass	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Wetland – open water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland – vegetative non forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Settlements	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other land	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Pre-1990 planted forest, to…																
Pre-1990 natural forest	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Pre-1990 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – annual	–	–	–	–	–	–	–	–	–	–	0.0	0.0	0.0	0.0	0.0	0.1
Cropland – perennial	–	–	–	–	–	–	–	–	–	–	0.0	0.0	0.0	0.0	0.0	0.1
Grassland – high producing	–	–	–	–	–	–	–	–	–	–	1.8	1.7	1.3	2.4	5.1	9.9
Grassland – low producing	–	–	–	–	–	–	–	–	–	–	0.5	0.5	0.5	0.7	1.1	1.7
Grassland – with woody biomass	–	–	–	–	–	–	–	–	–	–	0.3	0.3	0.3	0.4	0.7	0.9

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Wetland – open water	–	–	–	–	–	–	–	–	–	–	0.0	0.0	0.0	0.0	0.0	0.0
Wetland – vegetative non-forest	–	–	–	–	–	–	–	–	–	–	0.0	0.0	0.0	0.0	0.0	0.0
Settlements	–	–	–	–	–	–	–	–	–	–	0.0	0.0	0.0	0.0	0.1	0.1
Other land	–	–	–	–	–	–	–	–	–	–	0.0	0.0	0.0	0.0	0.0	0.1
From Post-1989 planted forest, to…																
Pre-1990 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – annual	–	–	–	–	–	–	–	–	–	–	–	–	0.0	0.0	0.0	0.0
Cropland – perennial	–	–	–	–	–	–	–	–	–	–	–	–	0.0	0.0	0.0	0.0
Grassland – high producing	–	–	–	–	–	–	–	–	–	–	–	–	0.5	1.5	1.3	1.5
Grassland – low producing	–	–	–	–	–	–	–	–	–	–	–	–	0.1	0.3	0.2	0.3
Grassland – with woody biomass	–	–	–	–	–	–	–	–	–	–	–	–	0.0	0.1	0.1	0.1
Wetland – open water	–	–	–	–	–	–	–	–	–	–	–	–	0.0	0.0	0.0	0.0
Wetland – vegetative non forest	–	–	–	–	–	–	–	–	–	–	–	–	0.0	0.0	0.0	0.0
Settlements	–	–	–	–	–	–	–	–	–	–	–	–	0.0	0.0	0.0	0.0
Other land	–	–	–	–	–	–	–	–	–	–	–	–	0.0	0.0	0.0	0.0
From Post-1989 natural forest, to…																
Pre-1990 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – annual	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – perennial	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grassland – high producing	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grassland – low producing	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grassland – with woody biomass	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Wetland – open water	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Wetland – vegetative non-forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Settlements	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Other land	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
From Cropland – annual																
Pre-1990 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 planted forest	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Post-1989 natural forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cropland – annual	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – perennial	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Grassland – high producing	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Grassland – low producing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – with woody biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland – open water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland – vegetative non forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Settlements	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other land	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Cropland – perennial, to…																
Pre-1990 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 planted forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Post-1989 natural forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cropland – annual	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cropland – perennial	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grassland – high producing	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Grassland – low producing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – with woody biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Wetland – open water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland – vegetative non forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Settlements	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other land	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Grassland – high producing, to…																
Pre-1990 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 planted forest	2.7	2.6	8.5	10.4	16.6	12.5	14.1	10.7	8.6	6.7	5.7	5.1	3.7	3.4	1.8	1.0
Post-1989 natural forest	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3
Cropland – annual	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2
Cropland – perennial	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.7	1.6	1.6	1.6	1.6
Grassland – high producing	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grassland – low producing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – with woody biomass	0.7	0.7	0.7	0.7	0.7	0.7	0.7	1.0	1.0	1.0	1.0	1.0	0.7	0.7	0.7	0.7
Wetland – open water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland - vegetative non forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Settlements	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Other land	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Grassland – low producing, to…																
Pre-1990 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 planted forest	8.0	7.8	25.3	31.0	49.5	37.2	42.1	32.1	25.8	20.1	16.9	15.2	11.1	10.0	5.3	3.0
Post-1989 natural forest	0.4	0.5	0.6	0.5	0.4	0.4	0.4	1.2	1.3	1.5	1.8	2.2	1.8	2.0	2.6	3.1
Cropland – annual	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cropland – perennial	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Grassland – high producing	54.7	54.7	54.7	54.7	54.7	54.7	54.7	56.0	56.0	56.0	56.0	56.0	54.7	54.7	54.7	54.7
Grassland – low producing	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grassland – with woody biomass	3.3	3.3	3.3	3.3	3.3	3.3	3.3	4.9	4.9	4.9	4.9	4.9	3.3	3.3	3.3	3.3

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Wetland – open water	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Wetland – vegetative non forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Settlements	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Other land	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
From Grassland – with woody biomass, to…																
Pre-1990 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 planted forest	2.8	2.7	8.9	10.9	17.4	13.1	14.8	11.3	9.1	7.1	5.9	5.3	3.9	3.5	1.9	1.1
Post-1989 natural forest	0.5	0.6	0.7	0.6	0.5	0.4	0.4	1.3	1.5	1.6	2.0	2.5	2.0	2.2	2.9	3.4
Cropland – annual	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cropland – perennial	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – high producing	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.3	1.3	1.3	1.3	1.3	1.1	1.1	1.1	1.1
Grassland – low producing	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.7	1.7	1.7	1.7	1.7	1.2	1.2	1.2	1.2
Grassland – with woody biomass	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Wetland – open water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland – vegetative non-forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Settlements	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other land	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Wetland – open water, to…																
Pre-1990 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 planted forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Post-1989 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – annual	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – perennial	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – high producing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – low producing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – with woody biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Wetland – open water	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Wetland – vegetative non-forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Settlements	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other land	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Wetland – vegetative non forest, To…																
Pre-1990 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 planted forest	0.0	0.0	0.1	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Post-1989 natural forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cropland – annual	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cropland – perennial	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – high producing	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Grassland – low producing	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Grassland – with woody biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland – open water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland – vegetative non forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Settlements	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other land	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Settlements, to…																
Pre-1990 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 planted forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Post-1989 natural forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cropland – annual	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – perennial	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – high producing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – low producing	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grassland – with woody biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Wetland – open water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland – vegetative non forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Settlements	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Other land	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Other land, To…																
Pre-1990 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 planted forest	0.1	0.1	0.2	0.3	0.4	0.3	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0
Post-1989 natural forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1
Cropland – annual	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cropland – perennial	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – high producing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – low producing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – with woody biomass	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Wetland – open water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland – vegetative non forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Settlements	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other land	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

From Pre-1990 natural forest, to…	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Pre-1990 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 planted forest	1.4	1.4	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Post-1989 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 natural regenerating forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – annual	0.0	0.0	–	–	0.0	–	–	0.0	0.0	0.0	–	–	–	–	–
Cropland – perennial	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Grassland – high producing	0.6	0.6	0.3	0.6	0.5	0.2	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1
Grassland – low producing	0.9	0.9	0.3	0.8	0.5	0.3	0.3	0.5	0.2	0.2	0.3	0.3	0.3	0.3	0.3
Grassland – with woody biomass	0.3	0.3	0.2	0.9	0.8	0.4	0.6	0.4	0.2	0.4	0.3	0.3	0.3	0.3	0.3

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Wetland – open water	0.0	0.0	–	0.0	–	0.0	–	–	–	0.0	–	–	–	–	–
Wetland – vegetative non-forest	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Settlements	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other land	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.1
From Pre-1990 planted forest, to…															
Pre-1990 natural forest	0.1	0.1	0.4	0.4	0.4	0.4	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Pre-1990 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – annual	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	–	–	–	–
Cropland – perennial	0.1	0.1	–	0.0	–	–	–	–	0.0	–	0.0	–	–	–	–
Grassland – high producing	12.4	16.5	2.4	3.2	3.5	2.6	4.6	5.8	4.0	2.5	2.3	1.8	1.4	1.3	0.6
Grassland – low producing	2.2	2.9	1.0	1.3	2.2	1.9	2.4	3.2	2.5	1.7	1.7	0.4	0.6	0.8	0.3
Grassland – with woody biomass	1.1	1.5	0.3	1.0	0.6	0.6	0.5	0.7	0.4	0.6	0.5	0.1	0.2	0.2	0.1
Wetland – open water	0.0	0.0	0.0	0.0	0.0	0.0	–	0.0	0.0	0.0	0.0	–	–	–	–
Wetland – vegetative non-forest	0.0	0.0	–	0.0	0.0	0.0	–	0.0	0.0	0.0	0.0	–	–	–	–
Settlements	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other land	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.0	0.0	0.1	0.0
From Post-1989 planted forest, to…															
Pre-1990 Natural Forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 Planted Forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 Planted Forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 Natural Forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – annual	0.0	0.0	0.0	–	0.0	0.0	0.0	0.1	0.0	0.0	0.0	–	–	–	–
Cropland – perennial	0.0	0.0	–	0.0	–	–	–	–	–	–	–	–	–	–	–
Grassland – high producing	1.3	3.1	0.9	0.9	1.0	1.1	0.8	1.6	1.2	1.5	1.5	1.5	0.6	0.8	0.3
Grassland – low producing	0.2	0.5	0.2	0.9	0.5	0.8	0.4	0.8	0.6	0.6	1.1	0.8	0.3	0.5	0.2
Grassland – with woody biomass	0.1	0.3	0.1	0.2	0.2	0.1	0.4	0.3	1.0	0.3	0.3	0.5	0.2	0.3	0.1
Wetland – open water	0.0	0.0	0.0	–	–	0.0	0.0	0.0	–	0.0	–	–	–	–	–
Wetland – vegetative non forest	0.0	0.0	–	–	0.0	–	–	–	0.0	–	0.0	–	–	–	–

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Settlements	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other land	0.0	0.0	–	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
From Post-1989 natural forest, to…															
Pre-1990 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – annual	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – perennial	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grassland – high producing	–	–	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Grassland – low producing	–	–	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – with woody biomass	–	–	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Wetland – open water	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Wetland – vegetative non forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Settlements	–	–	–	–	–	–	–	–	–	0.0	0.0	0.0	0.0	0.0	0.0
Other land	–	–	–	–	0.0	–	–	–	–	–	–	0.0	0.0	0.0	0.0
From Cropland – annual															
Pre – 1990 Natural Forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre – 1990 Planted Forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post – 1989 Planted Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–	–	–	–	–
Post – 1989 Natural Forest	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – annual	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – perennial	0.3	0.3	0.1	0.1	0.1	0.1	0.1	–	–	–	–	–	–	–	–
Grassland – high producing	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–
Grassland – low producing	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Grassland – with woody biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–	–	–	–	–
Wetland – open water	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland – vegetative non forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Settlements	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Other land	0.0	0.0	–	–	–	–	–	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
From Cropland – perennial, to…															
Pre-1990 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 planted forest	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 natural forest	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – annual	0.1	0.1	0.2	0.2	0.2	0.2	0.2	–	–	–	–	–	–	–	–
Cropland – perennial	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grassland – high producing	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – low producing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–	–	–	–	–
Grassland – with woody biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–	–	–	–	–
Wetland – open water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland – vegetative non forest	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Settlements	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other land	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Grassland – high producing, to…															
Pre-1990 natural forest	–	–	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–
Pre-1990 planted forest	–	–	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–
Post-1989 Planted Forest	0.4	0.4	1.1	1.6	2.0	3.2	3.1	0.8	0.7	0.7	0.7	0.6	0.7	2.1	3.3
Post-1989 Natural Forest	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2
Cropland – annual	1.2	1.2	0.0	0.0	0.0	0.0	0.0	–	–	–	0.0	–	–	–	–
Cropland – perennial	1.6	1.6	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Grassland – high producing	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grassland – low producing	0.0	0.0	0.6	0.6	0.6	0.6	0.6	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2
Grassland – with woody biomass	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Wetland – open water	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Wetland – vegetative non forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Settlements	0.8	0.8	0.5	0.5	0.5	0.5	0.5	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7
Other land	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Grassland – low producing, to…															
Pre-1990 natural forest	–	–	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–
Pre-1990 planted forest	–	–	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Post-1989 planted forest	1.3	1.2	1.8	3.9	5.4	10.7	10.2	3.6	2.5	2.5	3.0	4.6	6.0	19.1	29.2
Post-1989 natural forest	3.5	3.3	0.7	0.7	0.7	0.7	0.7	1.5	1.5	1.5	1.5	2.9	2.4	2.5	2.8
Cropland – annual	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–
Cropland – perennial	0.2	0.2	0.0	0.0	0.0	0.0	0.0	–	–	–	–	–	–	–	–
Grassland – high producing	54.7	54.7	7.5	7.5	7.5	7.5	7.5	12.3	12.3	12.3	12.3	12.1	12.0	12.0	12.0
Grassland – low producing	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grassland – with woody biomass	3.3	3.3	1.9	1.9	1.9	1.9	1.9	0.4	0.5	0.4	0.5	0.3	0.3	0.3	0.3
Wetland – open water	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland – vegetative non forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Settlements	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other land	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0
From Grassland – with woody biomass, to…															
Pre-1990 natural forest	–	–	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	–	–	–	–
Pre-1990 planted forest	–	–	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	–	–	–	–
Post-1989 planted forest	0.5	0.4	0.7	1.1	1.4	2.5	2.4	0.7	0.6	0.6	0.5	1.3	0.9	3.3	4.9
Post-1989 natural forest	3.9	3.7	1.0	1.0	1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.6
Cropland – annual	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cropland – perennial	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – high producing	1.1	1.1	1.4	1.4	1.4	1.4	1.4	0.8	0.8	0.9	0.8	0.6	0.5	0.5	0.5
Grassland – low producing	1.2	1.2	2.5	2.5	2.5	2.5	2.5	1.7	1.8	1.7	1.7	1.3	1.2	1.2	1.2
Grassland – with woody biomass	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Wetland – open water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland – vegetative non-forest	0.0	0.0	–	–	–	–	–	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Settlements	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other land	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
From Wetland – open water, to…															
Pre – 1990 Natural Forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre - 1990 Planted Forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post – 1989 Planted Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–	–	–	–	–
Post - 1989 Natural Forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – annual	–	–	0.0	0.0	0.0	0.0	0.0	–	–	–	–	–	–	–	–

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cropland – perennial	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Grassland – high producing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – low producing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – with woody biomass	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Wetland – open water	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Wetland – vegetative non-forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–	–	–	–	–
Settlements	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–
Other land	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–
From Wetland - vegetative non forest, To…															
Pre-1990 Natural Forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 Planted Forest	–	–	0.0	0.0	0.0	0.0	0.0	–	–	–	–	–	–	–	–
Post-1989 Planted Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Post-1989 Natural Forest	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – annual	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – perennial	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Grassland – high producing	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Grassland – low producing	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – with woody biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–
Wetland – open water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland – vegetative non forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Settlements	0.0	0.0	–	–	–	–	–	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other land	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Settlements, to…															
Pre-1990 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 planted forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 planted forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–	–	–	–	–
Post-1989 natural forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–	–	–	–	–
Cropland – annual	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – perennial	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Grassland – high producing	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Grassland – low producing	–	–	–	–	–	–	–	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Grassland – with woody biomass	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Wetland – open water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–	–	–	–	–
Wetland – vegetative non forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Settlements	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Other land	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
From Other land, to…															
Pre-1990 natural forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 planted forest	–	–	0.0	0.0	0.0	0.0	0.0	–	–	–	–	–	–	–	–
Post-1989 planted forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Post-1989 natural forest	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cropland – annual	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Cropland – perennial	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Grassland – high producing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–	0.0	–	–	–
Grassland – low producing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grassland – with woody biomass	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland – open water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland – vegetative non forest	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
Settlements	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other land	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

A3.2.4 Soils methodology

New Zealand uses a Tier 2 method to estimate soil carbon changes in mineral soils and follows the Tier 1 approach for organic soils.

Mineral soils

New Zealand's Tier 2 method for mineral soils involves estimating steady state soil organic carbon (SOC) stocks for each land use based on New Zealand soil data (described in more detail below). Changes in SOC stocks associated with land-use change are calculated according to the IPCC default method (IPCC, 2006a) using the equation:

$$\Delta C = [(SOC_0 - SOC_{(0\text{-}T)})/20] \times A \qquad (A3.2.1)$$

Where: ΔC = change in carbon stocks (tonnes)

SOC_0 = stable SOC stock in the inventory year (tonnes C ha^{-1})

$SOC_{(0\text{-}T)}$ = stable SOC stock T years prior to the inventory year (tonnes C ha^{-1})

A = land area of parcels with these SOC terms (hectares)

20 = IPCC default SOC stock transition period (year).

The SOC stock for each land use is characterised with country-specific data via the Soil Carbon Monitoring System (Soil CMS) model (McNeill and Barringer, unpublished; McNeill et al., unpublished). The correct operation of the Soil CMS model involves fitting the model to the soil carbon data set and then using the coefficients for the different land use categories for each land use transition (equation A3.2.1). The interpretation of the different land use effects is informed by multi-comparison significance.

Characterising SOC stocks: New Zealand's Soil Carbon Monitoring System

Unbiased estimates of SOC stocks associated with each land use in New Zealand are calculated by using country-specific data in the Soil CMS model. The operation of the Soil CMS model involves applying a linear statistical model to predict SOC stocks from land use, climate and soil order, which together regulate net SOC storage. The model also includes an additional environmental factor consisting of the product of slope and rainfall (hereafter, slope × rainfall), a term used as a proxy for erosivity, the potential for surface soil erosion to occur (Giltrap et al., unpublished). This allows for the explanatory effect of the land use category on SOC stocks to be isolated from other factors that affect SOC.

Two main assumptions underpin the operation of the Soil CMS model: first, the SOC values in the sample data set represent equilibrium SOC values for each stratified soil, climate and land use cell, and erosivity index; and second, changes in land use are the key drivers of change in SOC at the decadal scale, while all other changes due to soil type, climate or erosivity are assumed to be constant (McNeill et al., 2014). The model allows for an explanatory effect by land use category, so that estimates grouped by land use are unbiased where a specific land use category has an effect significantly different from the pooled soil carbon value from all land use categories. Where a land use category is a significant explanatory variable of SOC, incorporating land use in the model reduces the overall residual standard error associated with soil carbon (McNeill and Barringer, unpublished).

Soil carbon linear parametric model

The generalised least squares model used for the Soil CMS is a minimum variance unbiased estimator (Draper and Smith, 1998). This approach is consistent with the physically based soil carbon model outlined in the literature (Baisden et al., unpublished(b); Kirschbaum et al., unpublished; Scott et al., 2002; Tate et al., 2005).

The generalised least squares regression model for soil carbon in the 0–30-centimetre layer uses explanatory variables of the soil–climate factor, the land use category and slope × rainfall. This model is represented as an equation for the soil carbon $C_{i,j}^{0-30cm}$ in land use category *i* and soil–climate class *j* as:

$$C_{i,j}^{0-30\text{cm}} = M + L_i + S_j + b.SR + \varepsilon \qquad (A3.2.2)$$

Where: M = the mean soil carbon in the 0–30-centimetre layer for the combination of the reference level of land use (low producing grassland), the reference level for soil climate (MstTempHAC, i.e., 'moist temperate high activity clay'), and level ground

L_i = the effect of the *i*-th land use, specifying the difference in soil carbon relative to the reference land use (low producing grassland), in tonnes per hectare

S_j = the effect of the *j*-th soil–climate class relative to the reference level

$b.SR$ = the additional soil carbon for each unit of erosivity (slope × rainfall) (millidegree × 10^{-1})

ε = the model uncertainty.

The quantities M, L_i, S_j, as well as the slope × rainfall coefficient $b.SR$, are obtained by fitting a statistical model to the Soil CMS calibration data set; all other quantities are obtained from other data sets or from separate analyses (McNeill and Barringer, unpublished). For example, the mean value of the slope × rainfall must be obtained from national statistics of rainfall and a terrain slope map, which has been calculated from geographic information system (GIS) layers (Giltrap et al., unpublished).

More elaborate alternatives to the model have been considered but were not found to be significantly better than the model given in equation A3.2.2 (McNeill and Barringer, unpublished).

Soil data sets

Soil data for the Soil CMS inventory model come from five sources.

Historic soils: This data set is derived primarily from the National Soils Database,[8] with a small number of samples from various supplementary data sets; data from all sources were collected between 1935 and 2005. The National Soils Database represents soil profile data for over 1,500 soil pits scattered throughout New Zealand. These data contain the soil description following either the Soil Survey Method (Taylor and Pohlen, 1962) or *Soil Description Handbook* (Milne et al., 1995), as well as physical and chemical analyses from either the Landcare Research Environmental Chemistry Laboratory or the Department of Scientific and Industrial Research Soil Bureau. This data set was collated as the first stocktake of available soil data for national greenhouse gas reporting and, as such, underwent substantial quality-assurance and quality-control checks (Baisden et al., unpublished(b); Scott et al., 2002; Tate et al., 2005).

8 National Soils Database: https://viewer-nsdr.landcareresearch.co.nz/search.

Natural forest soils: This data set was gathered between 2001 and 2007 as part of the Natural Forest Survey, with soil subsampled on an 8-kilometre grid across the country (Garrett, unpublished; see section A3.2.5, 'National forest inventory' for more details of the 8-kilometre national grid system). The natural forest soils were important in the development of the Soil CMS model because they provided spatial balancing in areas of New Zealand not adequately covered by the historic soils data set.

Cropland data set: The third source of data originated as a set of intensively spatially sampled high producing grassland, annual cropland and perennial cropland records collected for other purposes, referred to as the cropland data set (Lawrence-Smith et al., 2010).

Wetlands: The fourth source of data comprises wetland soil data from a recent research effort to combine field data with analysis of the spatial distribution of current wetlands in New Zealand (Ausseil et al., 2015). This resulted in the addition of 21 wetland mineral soil samples to the Soil CMS data set (McNeill et al., 2014).

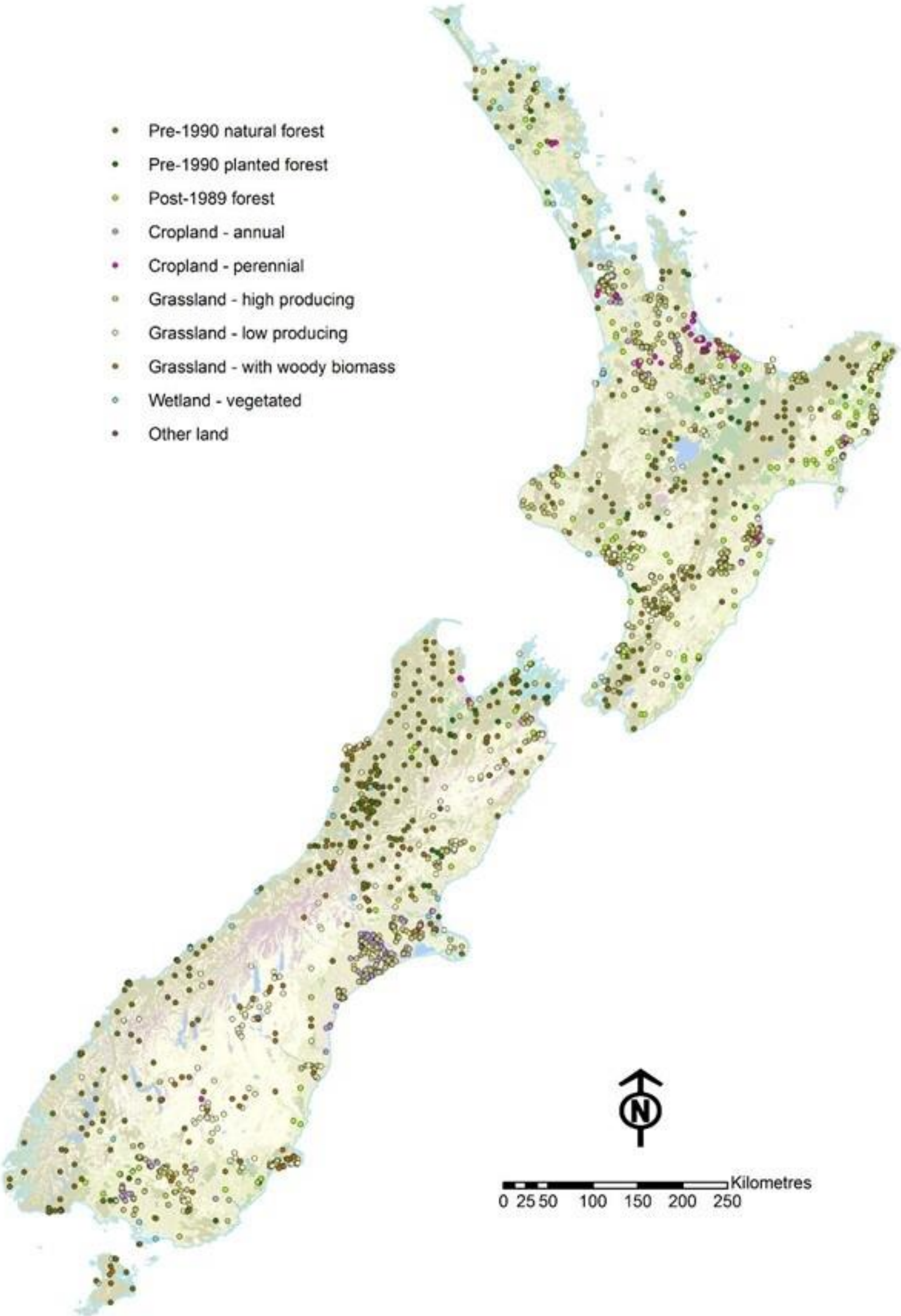
Post-1989 natural and planted forest data: This data set was added to the analysis in 2014. It contains data collected specifically for United Nations Framework Convention on Climate Change (Convention) reporting from 90 post-1989 forest sites across New Zealand (Basher et al., unpublished; Interpine Forestry Limited, unpublished).

Together, the five combined data sets cover most of New Zealand (see figure A3.2.5), including Stewart Island. Coverage does not extend to the Chatham Islands and other offshore islands. In addition to soil data, each record contains the site-specific climate, slope and rainfall attributes that are used in the analysis.

Due to a reliance on available data, coverage is dense in areas of agricultural activity, and the density of points varies widely between different regions (see figure A3.2.5). In addition, types of land use vary geographically: some are widespread (e.g., high producing grassland), whereas others are spatially constrained (e.g., cropland), so that the number of soil samples needed varies by land use (McNeill et al., unpublished).

The number of records associated with the different land use categories and soil orders varies widely, with the largest land use category *Grassland* having 1,216 samples and the smallest (*Other land*) only three samples. While efforts to collect or obtain additional data in under-sampled land use categories have been made since LUCAS was established, helping to reduce uncertainties, the effect on uncertainty due to the considerable variability of sampling points among the different land use types remains.

Figure A3.2.5 Soil samples in the Soil CMS model calibration data set



Settlements and the open water component of *Wetlands* were not used in the model due to lack of soil carbon data. Both land uses are assigned the reference level carbon stock, which is the same as low producing grassland, because no data are available for these land uses. The basis for using the reference level for *Settlements* is supported by the land use definition used for the category because it includes not only impervious surfaces but also green spaces (urban park land, golf courses and other recreational areas). These areas are likely to have elevated carbon stock levels compared with low producing grassland due to the treatments they receive.

Ancillary data

In addition to the soil data, the following ancillary data are used in the Soil CMS Model.

S-map: S-map is a contemporary digital soil spatial information system for New Zealand (Lilburne et al., 2012), which provides the best-available knowledge of the classification of the soil order consistent with the *New Zealand Soil Classification* (Hewitt, 2010). S-map coverage is not available for all the land area, because its focus is on regions of intensive agricultural use.

Fundamental Soils Layer: Where data on soil order were unavailable in S-map, data from the Fundamental Soils Layer[9] were used instead. The Fundamental Soils Layer provides GIS information on the expert-assessed classification of soil order and other soil or landscape attributes over New Zealand. It is generated from the NZLRI and National Soils Database.

Topographic information: Topographic slope information was estimated from a digital elevation model generated from Land Information New Zealand 1:50,000 scale topographic data layers including 20-metre contours, spot heights, lake shorelines and coastline.

Land use effects: Characterising soil carbon stocks

The 2014 version of the Soil CMS model used in this report builds on previous model versions (McNeill and Barringer, unpublished). The ‘land use effect’ (LUE) denotes the influence of land use on SOC stocks and corresponds to the model coefficients calculated for each land use. The LUE for a transition from low producing grassland to one of the other land uses can be obtained by using the coefficients of the soil carbon model (see table A3.2.5). Steady state SOC stocks for each land use (see table A3.2.6) are derived from the LUE coefficient in relation to the intercept (the reference of low producing grassland on high activity soils in a moist temperate climate, see table A3.2.5). These values are used in equation A3.2.3 (as SOC_0 and $SOC_{(0-T)}$) to calculate soil carbon changes due to land-use change.

Table A3.2.5 Land use effect coefficients with standard errors, *t*-values, and corresponding *p*-value significance estimates, extracted from full model results

Land use	Value	Standard error	*t*-value	*p*-value
Intercept: Low producing grassland	105.98	3.96	26.79	0.000
High producing grassland	–0.64	3.13	–0.21	0.8370
Grassland with woody biomass	–7.75	3.68	–2.11	0.0350
Perennial cropland	–17.54	6.37	–2.76	0.0059
Annual cropland	–16.21	4.45	–3.64	0.0003
Vegetated wetland	30.08	8.53	3.52	0.0004
Pre-1990 planted forest	–13.54	5.78	–2.34	0.0193
Post-1989 planted forest	–14.06	4.86	–2.90	0.0038
Pre-1990 natural forest	–13.73	3.70	–3.71	0.0002
Other land	–47.61	21.05	–2.26	0.0238

Source: McNeill and Barringer (unpublished)

Note: The model intercept (estimate for low producing grassland) is used for *Settlements* and *Wetlands – open water* land use categories due to lack of data.

[9] Fundamental Soils Layer: https://soils.landcareresearch.co.nz/tools/fsl/maps-fsl/

Table A3.2.6 Steady state soil organic carbon stocks, with 95 per cent confidence intervals, calculated from Soil CMS model

Land use	Steady state carbon SOC stock (t C ha^{-1})	95% confidence intervals (CI)	
		2.5% CI SOC stock (t C ha^{-1})	97.5% CI SOC stock (t C ha^{-1})
Pre-1990 natural forest	92.25	84.99	99.51
Pre-1990 planted forest	92.44	81.12	103.77
Post-1989 planted forest	91.92	82.40	101.44
Post-1989 natural forest	91.92	82.40	101.44
Grassland with woody biomass	98.23	91.02	105.43
High producing grassland	105.34	99.21	111.47
Low producing grassland	105.98	98.23	113.73
Perennial cropland	88.44	75.96	100.92
Annual cropland	89.77	81.04	98.49
Wetlands – open water	105.98	98.23	113.73
Wetlands – vegetated	136.06	119.33	152.78
Settlements	105.98	98.23	113.73
Other land	58.37	17.12	99.62

Source: Calculated from McNeill and Barringer (unpublished)

An Akaike information criterion (AIC) model selection procedure was used for the Soil CMS model. AIC is used to select the model that is the best trade-off between the complexity of the model and the goodness of fit. The use of the AIC value as a model selection and comparison mechanism is widely supported in the literature in soil modelling (Burnham and Anderson, 2002; Elsgaard et al., 2012; Ogle et al., 2007).

The selected model residual standard error is 41.3 tonnes per hectare. The spatial autocorrelation scale distance is 18.1 kilometres, with a nugget of 0.47 (McNeill and Barringer, unpublished). A correction for spatial correlation is necessary to reduce the potential spatial bias in SOC stock values that may occur from multiple samples that are located close to one another. These values are consistent with earlier analyses (McNeill, unpublished(a), (b)).

The uncertainty of the LUE (the change in soil carbon, assuming the transition is stable) between two land use categories in isolation is conceptually straightforward: two estimates of LUE are more likely to be significantly separated if their point estimates are farther apart after taking account of the covariance between the two land use effects. The standard error $\sigma_{i,j}$ of the LUE change for a transition between two land use categories with effects L_i and L_j is then estimated from:

$$\sigma_{i,j} = \sqrt{Var\ (L_i) + Var\ (L_j) - 2.Cov\ (L_i, L_j)} \qquad (A3.2.3)$$

Where: $Var(L_i)$ = the variance of land use effect i

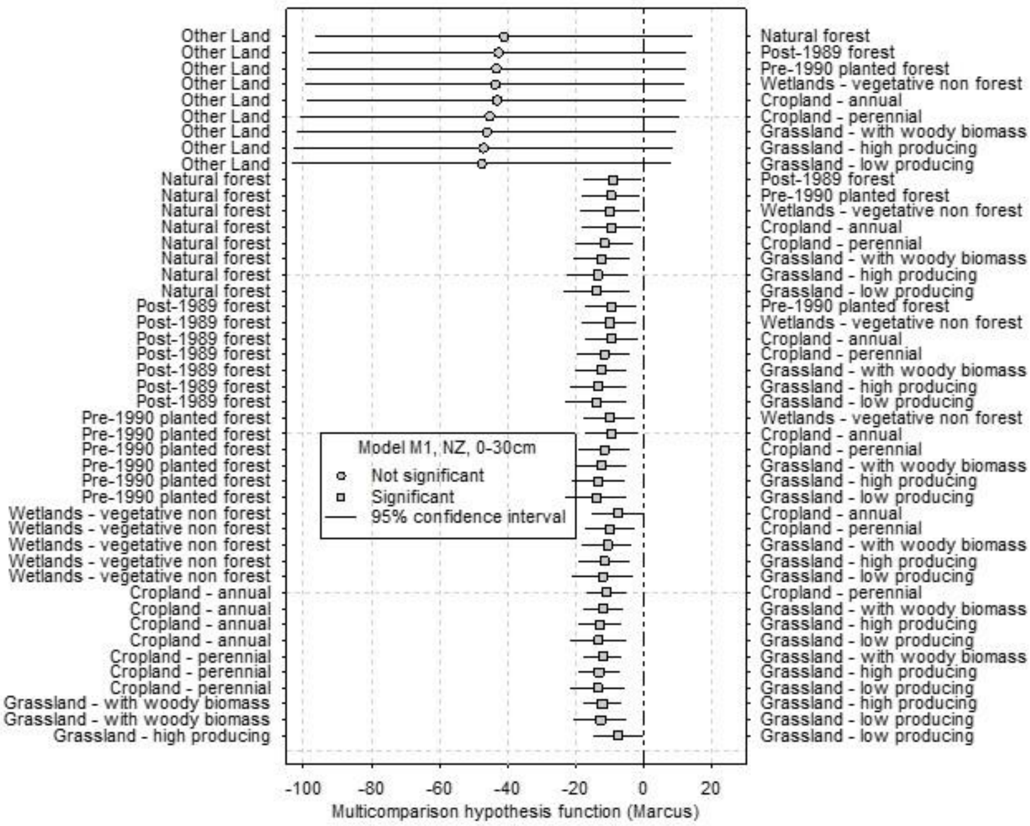
$Cov(L_i,L_j)$ = the covariance between land use effects L_i and L_j (McNeill and Barringer, unpublished; McNeill et al., unpublished).

Although equation A3.2.3 provides a mathematically straightforward way to estimate the significance of a single transition from one land use category to another (a comparison-wise significance), it is often desirable to be able to determine whether a number of land use categories are likely to be significantly different or essentially the same as an ensemble. As more comparisons are made between many different land use types, it becomes more likely that at least one of the LUE changes will be different as a result of random chance alone, resulting in an increase in the Type 1 error. Thus, the significance of all possible land use transitions must be calculated as a family of simultaneous comparisons (multiple comparison significance), rather than one at a time (McNeill and Barringer, unpublished).

To control the Type 1 error rate in multiple comparison significance testing for the soil carbon change model, all possible combinations of the land use categories were tested for equality (a two-sided test) simultaneously. For the Soil CMS model (McNeill and Barringer, unpublished), a closed-testing procedure described by Marcus et al. (1976) was used; this procedure is a general method for performing a number of hypothesis tests simultaneously implemented in the multi-comparison package in R (Bretz et al., 2010).

The closed-testing procedure described by Marcus et al. (1976) yielded point estimates and confidence intervals of a test statistic for each distinct combination of land use transitions, and the critical test is whether the confidence intervals include zero. All land use transition pairs were significant, except those involving *Other land* (see figure A3.2.6).

Figure A3.2.6 Result of applying the Marcus multi-comparison test to the adopted model



Source: McNeill and Barringer (unpublished)

Note: The marker is the estimated value for the specified transition to indicate significance, and the error bars represent the 95 per cent confidence interval of the test statistic. Land use transitions with point estimates and confidence intervals marked with a grey square are considered highly significant differences within the set of all possible land use transitions.

As the model results show (see figure A3.2.6), all transitions are significant in the multi-comparison sense, except those involving *Other land*. Land use transitions involving *Other land* contribute relatively little to the carbon change estimates, because they make up around 1.0 per cent of all land-use change detected between 1990 and 2020.

It is important to note that this interpretation of significance does not alter the method of calculation of the soil carbon change as a result of land use transition. In particular, it would not be correct to substitute a value of zero for the effect of a land use transition where the transition itself is not significant in the multi-comparison sense, because, if such a substitution were to be carried out, the calculation of the soil carbon would no longer be unbiased. Avoiding the bias in this manner also reduces the residual uncertainty of the soil carbon estimates. For this reason, the effect of all land use transitions ought to be included in calculations of soil carbon change (McNeill and Barringer, unpublished; McNeill et al., 2014).

Uncertainties in mineral soils

For the most part, uncertainties associated with the model coefficients (see table A3.2.6) are substantially reduced from the Tier 1 default value of 95 per cent. Land uses with higher uncertainties are those with few data points, such as *Other land*, or are dominant land uses in the country and, thus, occur across a range of environmental conditions, such as low producing grassland.

Uncertainties also arise from lack of soil carbon data for some soil, climate and land use combinations (Scott et al., 2002), and from variations in site selection, sample collection and laboratory analysis with data from different sources and time periods (Baisden et al., unpublished(b)). Other uncertainties in the Soil CMS model include: the assumption that soil carbon reaches steady state in all land uses and that there is a 20-year linear transition period to reach steady state; lack of soil carbon data and soil carbon change estimates below 0.3 metres; potential carbon losses from mass-movement erosion; and a possible interaction between land use and the soil–climate classification (Tate et al., 2004, 2005).

The inclusion of additional samples collected across a wider distribution has led to a reduction in the uncertainties for the land use effects, meaning all land use transitions, except for those involving *Other land*, are now significant in the multi-comparison sense (McNeill and Barringer, unpublished).

Source-specific quality control, quality assurance and verification

Quality-control and quality-assurance procedures have been adopted for all data collection and data analyses, to be consistent with 2006 IPCC Guidelines (IPCC, 2006a) and New Zealand’s inventory quality-control and quality-assurance plan:

- details of the quality-management system for data collection, laboratory analyses and database management of the National Soils Database are given in Wilde (2003)
- recent data collection, analyses and management methods are subject to the soils quality-control and quality-assurance plan
- the consolidated soils data set used within the Soil CMS model has been subject to further quality-assurance procedures (Fraser et al., unpublished).

The Soil CMS model has been subject to various forms of testing, validation and recalibration. Testing of the Soil CMS model was completed to evaluate its ability to predict SOC stocks at regional and local scales. The results from the Soil CMS have been compared against independent, stratified soil sampling for South Island low producing grassland (Scott et al., 2002) and for an area of the South Island containing a range of land-cover and soil-climate categories (Tate et al., 2003a, 2003b). A regional-scale validation exercise has also been performed using the largest climate–soil–land use combination cell, moist temperate and volcanic × high producing grassland, within dependent random sampling of 12 profiles taken on a fixed grid over a large area (2,000 square kilometres). Mean values derived from the random sampling were well within the 95 per cent confidence limits of the database values (Tate et al., 2005; Wilde et al., 2004). A second study validated the Soil CMS model for a different cell, dry temperate – high-activity clay – low producing grassland, finding no significant differences among field data, calibration data and model estimates (Hedley et al., 2012). Overall, tests have indicated that the Soil CMS model estimates SOC stocks reasonably well at a range of scales (Tate et al., 2005).

The system has also been validated for its ability to predict soil carbon changes between land uses at steady state for New Zealand's mainland-use change, grassland converted to planted forest. This was done by comparing the Soil CMS results with estimates based on paired sites (Baisden et al., unpublished(a); Tate et al., 2003a). This validation approach compares two nearby sites that have reasonably uniform morphological properties and were previously under a single land use, for which one site has changed to a different land use and sufficient time has elapsed for it to reach steady state values for soil carbon (Baisden et al., unpublished(a), unpublished(b)). This removes the influence that differing soil types, differing climatic conditions and previous land use regimes may have on soil carbon. Therefore, any resulting changes in soil carbon can be attributed to the most recent change in land use. In one study, results indicated that, once a weighting for forest species type was applied to the paired-site data set (to remove potential bias because Pinus radiata was under-represented in the analysis), the predictions of mean soil carbon from the Soil CMS model and paired sites were in agreement within 95 per cent confidence intervals (Baisden et al., unpublished(a), unpublished(b)). In a more recent study comparing low producing grassland and pre-1990 planted forests (Hewitt et al., 2012), the measured decrease in SOC under pre-1990 planted forest (–17.4 tonnes ha^{-1}) matched that determined by the Soil CMS model (McNeill et al., unpublished). This supported the Soil CMS model estimate (both in magnitude and direction) that forests planted pre-1990 have significantly lower SOC stocks than the low producing grassland and that the sampling depth of 0.3 metres was adequate for the estimation of SOC stock change.

The carbon stock estimates produced by the Soil CMS model reflect the type of soils in New Zealand (over 50 per cent being high activity clay soils) and the history of land use (fairly recent human settlement and forest clearance when compared with many other countries). As a comparison, when New Zealand reported using the Tier 1 default methodology (as in the 2011 submission), low producing grassland had the second highest SOC stock of all land uses (the highest being high producing grassland). The SOC stock for low producing grassland was also higher than for pre-1990 natural forests in that analysis.

Organic soils

Organic soils occupy a small proportion of New Zealand's total land area (1.0 per cent), and the area of organic soils subject to land-use change is around 0.7 per cent of New Zealand's total land area. New Zealand uses a Tier 1 method to estimate SOC stock change in organic soils.

The definition of organic soils is derived from the *New Zealand Soil Classification* (Hewitt, 2010), which defines organic soils as those soils with at least 18 per cent organic carbon in horizons at least 30 centimetres thick and within 60 centimetres of the soil surface.

New Zealand-specific climate and soil data are used to estimate the areas of organic soil found in each climate zone. Climate data are based on the temperature data layer of the Land Environments New Zealand classification (Leathwick et al., 2002). Soil-type data are based on the Fundamental Soils Layer associated with the NZLRI (Newsome et al., 2008) and converted to the IPCC classification (Daly and Wilde, unpublished). These data layers have been analysed in a GIS system to determine the areas of organic soils in warm and cold climatic zones. These areas are compared with the land use to determine the area of organic soils in each.

The Land Use, Land-Use Change and Forestry (LULUCF) organic soils definition is the same as that used for reporting under the Agriculture sector (Dresser et al., 2011).

New Zealand has used IPCC default emission factors for organic soils under the *Forest land*, *Grassland*, *Cropland, Wetlands* and *Settlements* categories (IPCC, 2006a) to estimate organic soil emissions (see table A3.2.7). IPCC guidance for organic soils under forest is limited to estimates associated with the drainage of organic soils in managed forests. In New Zealand, the drainage of pre-1990 natural forests does not occur, because the land is assumed to be in its natural state, and therefore no emissions are estimated from organic soils under natural forest. It is assumed that all planted forests on organic soils are drained before forest establishment. The temperate default emission factor for forest land is applied to the area of organic soils under planted forests to estimate emissions. The warm temperate and cold temperate default emission factors for the *Grassland*, *Cropland* and *Settlements* categories are applied in proportion to the area of land in New Zealand where the mean annual temperature is above or below 10°C respectively. New Zealand applies IPCC default emission factors for organic soils in the *Wetlands* category for areas under peat extraction. There are no default emission factors for organic soils under *Other land*; therefore, emissions from organic soils under this land use category are not estimated.

Table A3.2.7 New Zealand emission factors for organic soils

Land use	Climatic temperature regime	IPCC Tier 1 default emission factor applied and ranges (t C ha^{-1} yr^{-1})	Reference
Pre-1990 natural forest	Temperate	NA	IPCC guidance applies only to drained forest organic soils, which do not occur in natural forests in New Zealand (IPCC, 2006a, section 4.2.3.2).
Pre-1990 and post-1989 planted and natural forest	Temperate	0.68 (range 0.41–1.91)	IPCC (2006a, section 4.2.3.2, table 4.6)
Cropland	Cold temperate Warm temperate	5.0 ± 90% 10.0 ± 90%	IPCC (2006a, section 5.2.3.2, table 5.6)
Grassland	Cold temperate Warm temperate	0.25 ± 90% 2.5 ± 90%	IPCC (2006a, section 6.2.3.2, table 6.3)
Wetlands	NA	0.2 ± 90%	IPCC guidance applies to managed peatlands and flooded lands to which separate methodologies apply for soils. See IPCC, 2006a, chapter 7.
Settlements	Cold temperate Warm temperate	5.0 ± 90% 10.0 ± 90%	Cropland emission factors used (IPCC, 2006a, section 8.2.3.2)
Other land	NA	NE	No IPCC guidance is available (IPCC, 2006a, chapter 9.3.3)

Note: NA = not applicable; NE = not estimated.

Uncertainties in organic soils

New Zealand uses the IPCC Tier 1 default value for uncertainty of organic soils under the categories *Forest land*, *Grassland*, *Cropland, Wetlands* and *Settlements*, as given in the 2006 IPCC Guidelines (2006a, tables 4.6, 5.6, 6.3 and 7.4). These values vary from 40 per cent for managed forests to 90 per cent for the other land uses.

Further detail on uncertainty for each land use is discussed in the appropriate category sections. The same method is used for all years of reporting to ensure time-series consistency.

A3.2.5 Forest land methodologies

Calculation of harvest area

Total destocking area (all harvesting and deforestation) for each year is first calculated for all planted forests. This total destocking area is then partitioned into harvesting and deforestation areas for pre-1990 and post-1989 planted forests. The following steps are then carried out.

Total destocking area

1. Total destocking area between 1990 and 2012 is based on the harvested area reported in the NEFD (Ministry for Primary Industries, 2020) and adjusted to calendar years, plus the mapped deforestation area of post-1989 forest. The deforestation of post-1989 planted forest is added on because the NEFD is suspected to underestimate the destocking of small forest growers that are represented in the post-1989 planted forest estate.
2. Total destocking area between 2013 and 2020 is calculated by combining planted forest yield tables, the destocking age profile (section A3.2.5, 'Calculation of harvest area by age and forest age profile') and estimated roundwood volume removed from planted forests (Ministry for Primary Industries, 2021).
3. The change in approach from 2013 onwards is due to concerns regarding the completeness of the NEFD survey, which shows an increasing mismatch in total harvest volume estimates for recent years compared with Ministry for Primary Industries roundwood removal statistics (Ministry for Primary Industries, 2021).
4. Total destocking area for 2013 to 2020 is estimated as the area required to achieve the annual Ministry for Primary Industries roundwood volume estimate, based on the average volume per hectare removed on harvest (calculated from the harvest age profile combined with LUCAS yield tables). This approach provides greater consistency with roundwood volume estimates and carbon inputs in the *Harvested wood product* category from 2013 to 2020 (figure A3.2.10).

Deforestation area

1. Deforestation area from 1990 to 2017, for pre-1990 and post-1989 planted forest, is estimated from mapping data and supplementary statistics.
2. Deforestation area from 2017 onwards, for pre-1990 and post-1989 planted forest, is estimated from deforestation intentions survey results (Manley 2019, 2021; see section A.3.2.2).

Harvest area

1. The harvest area of post-1989 forest from 2005 to 2007 is based on personal communication with industry experts.
2. The harvest area of post-1989 forest from 2008 to 2016 is based on mapped harvest area data.
3. From 2017 onwards, a harvest fraction approach is used to estimate the total destocking area in post-1989 and pre-1990 planted forest. This approach applies the harvest age profile (table A3.2.8) to the forest age profile in both forest types, to determine the area available to be harvested in each. This provides an estimate of the destocking area to occur at each age in both forest types, as a proportion of the total destocking area.
4. Post-1989 harvest area from 2017 to 2020 is calculated as post-1989 total destocking area minus post-1989 deforestation area.
5. The harvest area of pre-1990 planted forest is then calculated for the whole time series (1990–2020) as total destocking area minus deforestation area (for both pre-1990 and post-1989 planted forest) and post-1989 harvest area.

Calculation of harvest area by age and forest age profile

Harvest and deforestation area by age

The harvest and deforestation area for pre-1990 and post-1989 planted forest is apportioned to an estimate of area by age (harvest age profile). This is because harvesting at a single age (28) years is not considered to reflect the actual harvesting that occurs and can lead to the harvest area exceeding the forest age available for harvest in some years. Estimating harvest area by age maintains the integrity of the forest age profile, limiting over-mature stands from growing on unharvested. The harvest or deforestation area by age is then combined with a yield table look-up value to determine carbon losses.

A total destocking age profile is first calculated, which represents the percentage of total destocking (harvest and deforestation area) at each age class across all planted forest (table A3.2.8). The destocking age profile is derived from the loss of forest area in each age class with each annual update to the NEFD forest age profile (Ministry for Primary Industries, 2020). The loss in forest area at each age class with the update is combined to create an average destocking age profile, as a percentage of total destocking area. The destocking age profile is then fitted to the average harvest age for each year, to capture the impact of the change in harvest age through time.

The average harvest age is sourced from annual NEFD publications from 1995 to 2019 (Ministry for Primary Industries, 2020). The average harvest age is converted to calendar years and a three-year moving average is applied to smooth out any year-to-year fluctuations. An average harvest age of 28 years is assumed for 1990 to 1995.

The destocking age profile is then combined with the annual harvest and deforestation area in pre-1990 and post-1989 planted forest. This gives an estimate of harvest and deforestation area by age for each forest type. The final harvest age by age in 2020 is demonstrated in figure A3.2.7 for pre-1990 planted forest and in figure A3.2.8 for post-1989 planted forest.

Both pre-1990 and post-1989 planted forest share the same underlying destocking age profile. Therefore, as the harvest area of post-1989 planted forest increases (harvesting young-age stands) the average harvest age of pre-1990 planted forest increases. This ensures that the average harvest age of all planted forest is retained across all forest types.

Forest age profile

Post-1989 planted forest

The forest age profile in post-1989 planted forest is driven by the area of new planting from 1990 onwards (see section A.3.2.2), adjusted for any harvesting or deforestation area.

Pre-1990 planted forest

The forest age profile in pre-1990 planted forest is driven by annual harvest area for all stands planted after 1990. A one-year lag between harvesting and replanting is assumed. This means an estimated harvest area of 18,789 hectares in 1990 will result in replanting of the same area in 1991.

Annual planting area before 1990 is established to meet the required harvest and deforestation area by age estimates from 1990 onwards. This means an estimated 3,000 hectares of forest harvested at age 30 in 2010 would require that same area to have been planted in 1980. The planting area by year required is then apportioned into new planting, based on the area converted to pre-1990 planted forest from 1962 to 1989 (see section A.3.2.2), or assigned harvest and replanting events.

The forest age profile for the remaining forest area that is not subject to harvest or deforestation after 1990 is estimated from the NEFD forest age profile. The forest age profile in the most recent reporting year for all forest planted before 1990 is estimated by multiplying the area of this forest by the proportion of forest in each age from the NEFD. This results in the area in each age group being slightly higher than the NEFD estimate, this difference can be seen in forest aged over 30 years in figure A3.2.11. The forest area by age in the most recent report year is then assigned a corresponding plant date.

Table A3.2.8 Proportion of total destocking area by age across all planted forest, 1990–2020

	Destocking age by age (per cent)																														
Year	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
2020	0.0	1.0	1.1	0.9	1.3	1.2	1.4	0.8	1.6	1.5	3.0	7.2	10.6	12.6	12.2	10.6	8.5	6.8	5.0	3.4	2.3	2.0	1.5	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2
2019	0.0	1.0	1.1	0.9	1.3	1.2	1.4	0.8	1.6	1.5	3.0	7.2	10.6	12.6	12.2	10.6	8.5	6.8	5.0	3.4	2.3	2.0	1.5	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2
2018	0.4	1.0	1.0	1.0	1.2	1.2	1.2	1.1	1.5	2.0	4.5	8.4	11.3	12.4	11.6	9.8	7.9	6.1	4.4	3.0	2.2	1.8	1.3	0.9	0.6	0.6	0.5	0.3	0.2	0.2	0.2
2017	0.4	1.0	1.0	1.0	1.2	1.2	1.2	1.1	1.5	2.0	4.5	8.4	11.3	12.4	11.6	9.8	7.9	6.1	4.4	3.0	2.2	1.8	1.3	0.9	0.6	0.6	0.5	0.3	0.2	0.2	0.2
2016	0.5	1.0	1.0	1.0	1.2	1.3	1.1	1.2	1.5	2.1	4.9	8.8	11.5	12.4	11.4	9.6	7.7	6.0	4.3	2.9	2.2	1.7	1.2	0.8	0.6	0.5	0.4	0.3	0.2	0.2	0.2
2015	0.3	1.0	1.0	1.0	1.2	1.2	1.2	1.1	1.6	1.9	4.2	8.2	11.2	12.4	11.7	10.0	8.0	6.3	4.5	3.1	2.2	1.8	1.3	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2
2014	0.8	1.0	0.9	1.2	1.2	1.3	0.9	1.4	1.5	2.6	6.2	9.8	12.1	12.3	11.0	9.0	7.2	5.4	3.8	2.6	2.0	1.6	1.1	0.8	0.6	0.5	0.4	0.2	0.2	0.2	0.2
2013	0.7	1.0	0.9	1.1	1.2	1.3	1.0	1.4	1.5	2.5	5.9	9.6	12.0	12.3	11.1	9.1	7.3	5.6	3.9	2.7	2.1	1.6	1.1	0.8	0.6	0.5	0.4	0.3	0.2	0.2	0.2
2012	0.8	1.0	0.9	1.2	1.2	1.4	0.9	1.5	1.5	2.6	6.3	9.9	12.2	12.2	10.9	8.9	7.1	5.4	3.7	2.5	2.0	1.6	1.1	0.7	0.6	0.5	0.4	0.2	0.2	0.2	0.2
2011	0.6	1.0	0.9	1.1	1.2	1.3	1.1	1.3	1.5	2.3	5.3	9.1	11.7	12.3	11.3	9.4	7.5	5.8	4.1	2.8	2.1	1.7	1.2	0.8	0.6	0.5	0.4	0.3	0.2	0.2	0.2
2010	0.7	1.0	0.9	1.1	1.2	1.3	1.0	1.4	1.5	2.4	5.8	9.5	11.9	12.3	11.1	9.2	7.4	5.6	3.9	2.7	2.1	1.7	1.1	0.8	0.6	0.5	0.4	0.3	0.2	0.2	0.2
2009	0.9	1.1	0.9	1.2	1.2	1.4	0.9	1.5	1.4	2.8	6.8	10.3	12.4	12.2	10.7	8.7	6.9	5.2	3.6	2.4	2.0	1.6	1.0	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.2
2008	1.0	1.1	0.9	1.3	1.2	1.4	0.8	1.6	1.5	2.9	7.2	10.6	12.5	12.2	10.6	8.5	6.8	5.0	3.4	2.3	2.0	1.5	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.2
2007	1.0	1.0	0.9	1.3	1.2	1.4	0.9	1.6	1.5	3.1	7.3	10.7	12.5	12.1	10.5	8.4	6.7	5.0	3.4	2.3	1.9	1.5	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.2
2006	1.0	1.0	0.9	1.3	1.2	1.4	0.9	1.6	1.5	3.1	7.3	10.7	12.5	12.1	10.5	8.4	6.7	5.0	3.4	2.3	1.9	1.5	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.2
2005	1.0	1.0	0.9	1.2	1.2	1.3	1.0	1.6	1.7	3.8	7.9	11.0	12.5	11.9	10.2	8.2	6.4	4.7	3.2	2.3	1.9	1.4	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.1
2004	1.0	1.0	1.1	1.2	1.3	1.1	1.2	1.5	2.2	5.1	8.9	11.7	12.4	11.4	9.6	7.7	5.9	4.2	2.9	2.2	1.7	1.2	0.8	0.6	0.5	0.4	0.3	0.2	0.2	0.2	0.1
2003	1.1	0.9	1.1	1.2	1.3	1.0	1.4	1.5	2.4	5.8	9.5	12.0	12.4	11.2	9.3	7.4	5.7	4.0	2.7	2.1	1.7	1.1	0.8	0.6	0.5	0.4	0.3	0.2	0.2	0.2	0.1
2002	1.1	0.9	1.2	1.2	1.4	0.9	1.5	1.5	2.7	6.7	10.3	12.4	12.3	10.9	8.9	7.1	5.3	3.6	2.5	2.0	1.6	1.0	0.7	0.6	0.5	0.4	0.2	0.2	0.2	0.2	0.0
2001	1.1	0.9	1.3	1.2	1.4	0.8	1.7	1.4	3.0	7.4	10.9	12.8	12.3	10.7	8.5	6.8	5.0	3.4	2.3	2.0	1.5	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.2	0.0
2000	1.1	0.8	1.3	1.1	1.5	0.7	1.7	1.4	3.1	7.8	11.2	13.0	12.3	10.5	8.3	6.6	4.9	3.2	2.2	1.9	1.5	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.2	0.0
1999	1.1	0.9	1.2	1.2	1.3	1.0	1.4	1.5	2.5	5.9	9.7	12.1	12.4	11.1	9.2	7.3	5.6	3.9	2.7	2.1	1.7	1.1	0.8	0.6	0.5	0.4	0.3	0.2	0.2	0.2	0.0
1998	1.0	1.0	1.0	1.2	1.2	1.2	1.1	1.5	2.0	4.5	8.5	11.4	12.5	11.6	9.9	7.9	6.2	4.5	3.0	2.2	1.8	1.3	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.1
1997	1.0	1.0	1.0	1.2	1.2	1.2	1.0	1.6	1.8	4.1	8.1	11.2	12.5	11.8	10.1	8.1	6.3	4.6	3.1	2.2	1.8	1.4	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.1
1996	1.0	1.0	1.0	1.2	1.2	1.3	1.0	1.6	1.8	3.9	8.0	11.1	12.5	11.8	10.1	8.1	6.4	4.7	3.2	2.3	1.9	1.4	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.1

															Destocking age by age (per cent)																
Year	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**
1995	1.0	1.0	0.9	1.2	1.2	1.3	1.0	1.6	1.7	3.8	7.9	11.0	12.5	11.9	10.2	8.2	6.4	4.7	3.2	2.3	1.9	1.4	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.1
1994	1.0	1.0	0.9	1.2	1.2	1.3	0.9	1.6	1.6	3.4	7.5	10.8	12.5	12.0	10.4	8.3	6.6	4.9	3.3	2.3	1.9	1.5	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.1
1993	1.0	1.0	0.9	1.2	1.2	1.3	0.9	1.6	1.6	3.4	7.5	10.8	12.5	12.0	10.4	8.3	6.6	4.9	3.3	2.3	1.9	1.5	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.1
1992	1.0	1.0	0.9	1.2	1.2	1.3	0.9	1.6	1.6	3.4	7.5	10.8	12.5	12.0	10.4	8.3	6.6	4.9	3.3	2.3	1.9	1.5	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.1
1991	1.0	1.0	0.9	1.2	1.2	1.3	0.9	1.6	1.6	3.4	7.5	10.8	12.5	12.0	10.4	8.3	6.6	4.9	3.3	2.3	1.9	1.5	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.1
1990	1.0	1.0	0.9	1.2	1.2	1.3	0.9	1.6	1.6	3.4	7.5	10.8	12.5	12.0	10.4	8.3	6.6	4.9	3.3	2.3	1.9	1.5	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.1

Figure A3.2.7 Harvest area by age for pre-1990 planted forest in 2020

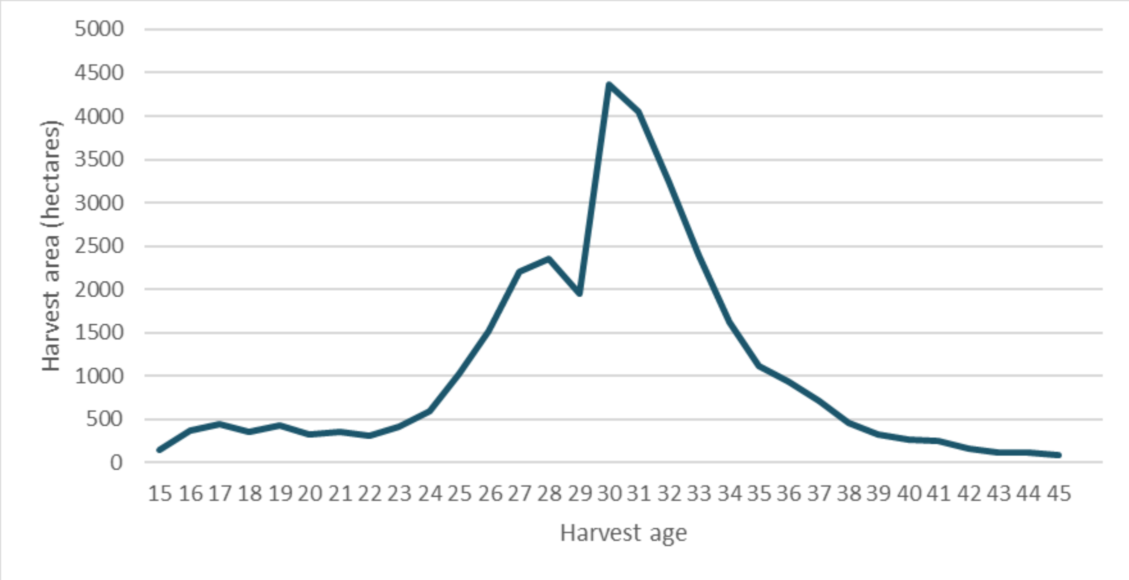
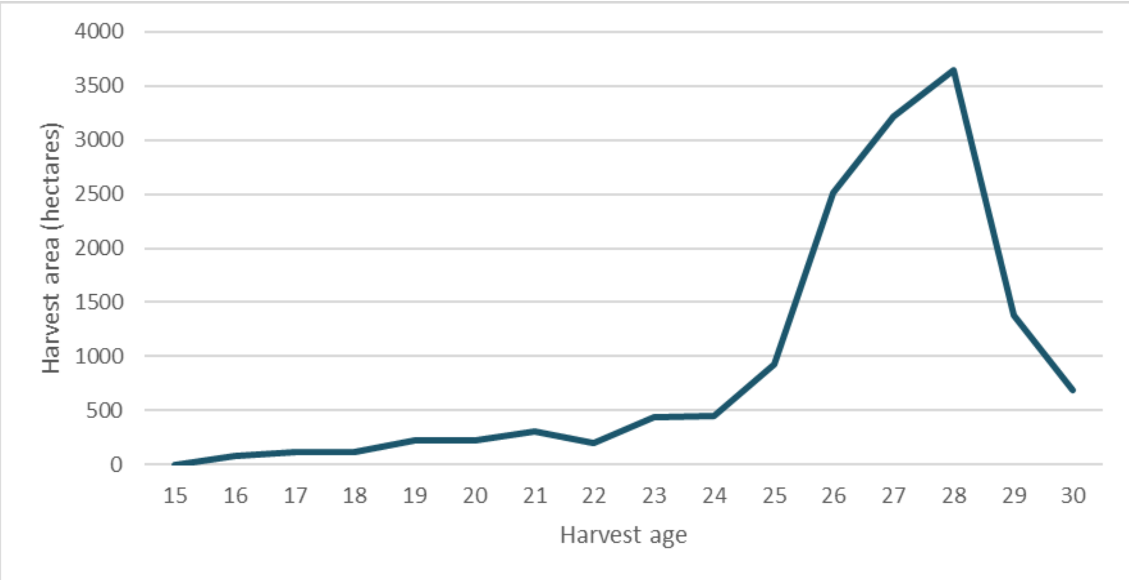


Figure A3.2.8 Harvest area by age for post-1989 planted forest in 2020



National forest inventory

New Zealand has established a sampling framework for forest inventory purposes based on an 8-kilometre national grid system (8-kilometres north–south by 8–kilometres east–west). The grid has a randomly selected origin and provides an unbiased framework for establishing plots for field and/or Light Detection and Ranging (LiDAR) measurements. The network is further subdivided into a 4-kilometre grid for measurement of post-1989 forest. Forest monitoring plots are established and measured where a grid point falls in the land use to be sampled.

Pre-1990 natural forest

A national monitoring programme designed to enable unbiased estimates of carbon stock and change for New Zealand's natural forests was developed between 1998 and 2001 (Coomes et al., 2002). Permanent circular sample plots of 0.13 hectares (i.e., 20 metre diameter) were installed systematically on the 8-kilometre grid across New Zealand's natural forests and these were first measured (t_1) over five years between 2002 and 2007.

The plots were sampled using vegetation monitoring methods designed specifically for the purpose of calculating carbon stocks (Payton et al., 2004). A 20 × 20 metre square plot sits nested at the centre of each circular plot where all live stems with diameter at breast height (1.35 metres) greater or equal to 2.5 centimetres are measured. Stems greater than 60 centimetres diameter at breast height are sampled on the circular plot.

Re-measurement of the plot network provides repeat data suitable for calculating carbon stock change in natural forest. The first re-measurement of the plot network was completed between 2009 and 2014 (t_2) following a revised methodology for re-measurement purposes (Ministry for the Environment, unpublished). For the third round of measurement, the programme is continuing at a reduced rate, with plots being measured on a 10-year cycle. Measurement of plots for this round began in 2014 and is scheduled for completion in 2024. Data collection on the natural forest plot network has recently transitioned (2020–21 field season) to an electronic data capture system. It had previously relied on a paper-based system. This will improve data quality and reduce the time between field collection and analysis.

At each plot, data are collected to calculate the volumes of trees, shrubs and dead organic matter present. These measurements are then used to estimate the carbon stocks for the biomass pools of:

- living biomass (comprising above-ground biomass and below-ground biomass)
- dead organic matter (comprising dead wood and litter).

Table A3.2.9 summarises the method used to calculate the carbon stock in each biomass pool from the information collected at each plot.

Table A3.2.9 Summary of methods used to calculate New Zealand's natural forest biomass carbon stock from plot data

Pool		Method	Source
Living biomass	Above-ground biomass	Plot measurements; allometric equations	Paul et al., 2021
	Below-ground biomass	Estimated as the ratio of below-ground biomass to above-ground biomass	Paul et al., 2021; Easdale et al., 2019
Dead organic matter	Dead wood	Modelled from plot measurements; allometric equations	Garrett et al., 2019; Paul et al., 2021; Kimberley et al., 2019
	Litter	Plot samples; laboratory analysis of samples collected at plots	Paul et al., 2021; Garrett, unpublished

Living biomass

Living biomass is separated into two carbon pools.

1. Above-ground biomass. The carbon content of individual trees and shrubs is calculated using species-specific allometric relationships between diameter, height and wood density (for trees), a non-specific conversion factor with diameter and height (for tree ferns) or volume and biomass (for shrubs) (Beets et al., 2012b; Paul et al., 2021). Shrub volumes are converted to carbon stocks using species- and/or site-specific conversion factors determined from the destructive harvesting of reference samples. Carbon fractions of 0.51 for gymnosperms and 0.48 for broadleaf species (IPCC, 2006a).

2. Below-ground biomass. The below-ground biomass was estimated for each individual tree based on an estimate of the root:shoot ratio for that species (the ratio of the below-ground biomass to above-ground biomass). Applying the root:shoot ratios as published in Easdale et al. (2019) has been included to address the expert review team recommendation L.4, 2019 (FCCC/ARR/2019/NZL, UNFCCC, 2020). Tree and shrub species in different taxonomic groups were assigned different root:shoot ratios, as outlined in (Paul et al., 2021) and are summarised in table A3.2.10.

Table A3.2.10 Summary of root:shoot ratios applied to the different taxonomic groups in pre-1990 natural forest

Taxonomic group	Root:shoot ratio
Angiosperm trees (> 5 cm diameter at breast height)	0.234
Monocots (palms and cabbage trees)	0.194
Gymnosperms and shrubs	0.235

Dead organic matter

Dead organic matter is separated into two carbon pools.

1. Dead wood. The carbon content of dead standing trees is determined in the same way as live trees but excludes branch and foliage biomass calculations. The carbon content of the fallen wood and stumps is derived from the volume of the piece of wood, its species (if able to be identified) and what stage of decay it is at. Dead wood comprises woody debris with a diameter greater than 10 centimetres. The dead wood pool is difficult to measure in the field (particularly wood that is in an advanced state of decay) and is currently being underestimated by the monitoring programme (Kimberley et al., 2019). An adjustment factor, derived by an approach developed by Kimberley et al. (2019), was applied to correct for this (Paul et al., 2021). Deadwood is measured on all new plots and modelled for re-measured plots using initial measurements, inputs from mortality and known decay rates (Paul et al., 2021).
2. Litter. The carbon content of the fine debris is calculated by laboratory analysis of sampled material. The samples are bulked by sampling depth (0–10 centimetres, 10–20 centimetres, 20–30 centimetres) and the total fine earth mass is measured and then analysed for carbon content. Litter comprises fine woody debris (dead wood from 2.5 centimetres to 10.0 centimetres in diameter), the litter (all material less than 2.5 centimetres in diameter) and the fermented humic horizons. Samples were taken at around one-third of the natural forest plots.

Carbon stock change

Carbon stock change in the living biomass pool is calculated using the methods described in Paul et al. (2021). In this method, carbon stock change for each plot is calculated by summing the stock change for each individual live stem and subtracting the summed carbon at t_1 for individual stems that died in the period between t_1 and t_2. To account for ingrowth (stems that have reached the 2.5 centimetre diameter at breast height threshold since the last plot measurement) and missing measurements, the diameter of trees measured at t_2 that were not measured at t_1 were predicted and used in the calculation of stock change, provided that the diameter at t_2 was above the threshold for field measurement (e.g., 2.5 centimetres for the embedded 0.04 hectare square plot, and 60 centimetres for the 0.13 hectare circular plot). The total summed carbon is calculated for each plot, and the mean change across all plots measured twice is used as the national average. New Zealand has inventoried its pre-1990 natural forest at two points in time: 2002 to 2007 and 2009 to 2014 (the third round of measurements is under way and due for completion in 2024). The average measurement date of the first measurement period is 2004 and average measurement date of the second measurement period is 2011. Pre-1990 natural forest was classified into tall and regenerating subcategories using the 2008 land cover mapped in Land Cover Database version 5.0. Carbon stock change was then calculated separately for both subcategories.

Between 2002 and 2007 and 2009 and 2014, the regenerating forest component of New Zealand's pre-1990 estate had a rate of carbon stock change of 0.43 ± 0.51 tonnes C ha^{-1} yr^{-1} (estimated from Paul et al., 2021). The tall forest component changed very little over the same period (–0.01 ± 0.19 tonnes C ha^{-1} yr^{-1}) The data for both components are extrapolated back to 1990 and forward to the current inventory year to calculate stock changes for all years. The combined overall net change across all pre-1990 natural forest was indistinguishable from zero (0.03 ± 0.18 tonnes C ha^{-1} yr^{-1}; estimated from Paul et al., 2021). Carbon stock change in regenerating forest was driven primarily by an increase in live above-ground biomass of 0.36 ± 0.26 tonnes C ha^{-1} yr^{-1} (Paul et al., 2021). Carbon stock change in tall forest was driven primarily by a decrease in live above-ground biomass of –0.01 ± 0.15 tonnes C ha^{-1} yr^{-1}.

In an effort to reduce sampling uncertainty and fulfil the practical recommendations made by Holdaway et al. (2014) and the related expert review team recommendation L.1, 2019 (FCCC/ARR/2019/NZL, UNFCCC, 2020), several improvements have been implemented in the management of the natural forest plot measurement programme and analysis of data over time. First, the number and size of plots included in carbon stock and stock change analyses have increased through time. A total of 874 plots were included in Holdaway et al. (2017). This has increased to 1,030 plots for updated carbon stock calculations and 908 plots for updated carbon stock change calculations in Paul et al. (2021). Paul et al. (2021) included stems from a larger plot area (0.13 hectares) than in previous analyses, which only included stems from the nested 20 × 20 metre (0.04 hectare) plot (Holdaway et al., 2017).

Second, changes to the approach for estimating dead organic matter (i.e., adjusting for under-estimation of field measurements) represents an improvement in stock and stock change estimates. Third, the stem-level carbon stock change methods used by Paul et al. (2021) described above account for ingrowth stems and missed stems. This reduces bias in the carbon stock change estimate and represents an improvement on previous methods (Holdaway et al., 2017) where a simple stock change approach was used. The effect of some of these improvements to methodologies has been outlined and quantified in table 8 of Pau et al. (2021).

Post-1989 natural forest

Estimates of carbon stock and stock change in post-1989 natural forest are calculated using measurements taken from the field inventory. The inventory samples post-1989 natural forest using 0.13 hectare permanent sample plots on the systematic 4-kilometre grid. Twenty plots in post-1989 natural forest were established and measured for the first time in 2012. A second round of measurements, on 25 plots was conducted in 2019. A yield table was generated from the plot measurements to provide estimates of carbon stock change (Paul et al. unpublished(b)). The plot network design is described in Beets et al. (2012a, 2014b), and detailed methods for plot measurement are given in the data collection manual (Ministry for the Environment, unpublished).

Living biomass and dead organic matter

At permanent sample plots within post-1989 natural forest, measurements are taken of standing and fallen, live and dead plants. Destructive biomass samples have also been taken outside of the plots and are used to create plot-specific allometric equations, which are then applied to these measurements to calculate above-ground live biomass.

The biomass of standing dead wood (woody debris with a diameter greater than 10 centimetres) and litter (woody debris with a diameter of less than 10 centimetres) is measured and calculated using the same methods as used in pre-1990 natural forest described above.

Biomass sampling on post-1989 natural forest plots includes the determination of plant age, which enables the back-casting of biomass through time. Back-cast estimates of biomass are used to calculate carbon stock change. The method used to do this was developed and validated using plots for which multiple measurements in time had been obtained and for which carbon stock change was able to be measured directly (Beets et al., 2014a). Full methods for the calculation of carbon stock and stock change in post-1989 natural forest are described in Beets et al. (2014b) and Paul et al. (unpublished(b)).

Carbon stock change in the living biomass pool is calculated using the methods described in Paul et al. (unpublished (b)). In addition, a post-1989 natural forest yield table is included and is used in conversions from *Grassland with woody biomass* (see table A3.2.16). The yield table starts at the same carbon stock as *Grassland with woody biomass* resulting in no emissions from biomass in the first year of conversion because this conversion represents ecological succession.

The carbon stock estimate for post-1989 natural forest is 38.55 ± 10.23 tonnes C ha^{-1} (at the 95 per cent confidence interval) as at 31 December 2019 (Paul et al. unpublished(b)). The average rate of carbon sequestration in post-1989 natural forest between 2012 and 2019 was 2.48 tonnes C ha^{-1} yr^{-1} (calculated from Paul et al., unpublished(b)). This rate is slightly higher than previously reported rates of carbon sequestration in regenerating forest in New Zealand (Carswell et al., 2012; Trotter and MacKay, unpublished). This possibly reflects differences in the composition of species that were targeted in these studies (Paul et al. unpublished(b)).

Planted forest

The planted forest inventory consists of 749 circular 0.06-hectare plots established on the systematic 8-kilometre grid and nested 4-kilometre grid as described above (339 in pre-1990 planted forest and 410 in post-1989 planted forest). These plots are ground measured using procedures described in Herries et al. (unpublished). Stand records and ground measurements are recorded between June and October at each plot. Measurements include tree age; stocking (stems per hectare); stem diameters at breast height of live and dead trees; a sample of tree total heights for each tree species; pruned heights; and the timing of pruning and thinning activities. Ground plot centres were located using a 12-channel differential global positioning system (GPS) for accurate LiDAR co-location and relocation for future measurements (Beets et al., 2011a; 2012a).

Living biomass and dead organic matter

The crop tree plot data collected from the planted forest inventories are modelled using a forest carbon modelling system (the Forest Carbon Predictor, version 4.12; Beets and Garrett, 2018; Beets et al., 2018a, 2018b; Paul et al., unpublished(a); Paul and Wakelin, unpublished) developed for the two most common plantation tree species in New Zealand: *Pinus radiata* and *Pseudotsuga menziesii*. To enable predictions of carbon stocks and changes in New Zealand's planted forests, this system integrates:

- the 300 Index growth model (Kimberley and Dean, 2006) for Pinus radiata
- the 500 Index growth model for Douglas fir (Knowles, 2005)
- a wood density model (Beets et al., 2007)
- a stand tending model (Beets and Kimberley, unpublished)
- the C_Change carbon allocation model (Beets et al., 1999).

The individual components of the Forest Carbon Predictor are explained below and illustrated in figure A3.2.9.

The 300 Index and 500 Index growth models produce a productivity index for forest plots derived from stand parameters. These stand parameters include stand age, mean top height, basal area, stocking and stand silvicultural history. Plot latitude and altitude are also required to run the models. The growth models use these parameters to predict stem volume under bark over a full rotation (planting to harvest). A specific productivity index is produced for each plot, which is then used to estimate the total live and dead stem volume by annual increment. The growth models account for past and future silvicultural treatments using plot data, information on past silvicultural treatments and assumptions of future management events based on plot observations and standard regimes (Beets and Kimberley, unpublished).

The wood density model within the Forest Carbon Predictor uses site mean annual temperature, soil nitrogen fertility, ring age and stocking to determine the mean density of stem wood growth sheaths produced annually in *Pinus radiata*. Wood density is an important variable in the estimation of carbon. Of the parameters entered into the wood density model, temperature and stand age have the greatest influence on wood density, followed by site fertility and stocking. The combined result of these individual effects can be substantial, as shown in table A3.2.11 (Beets et al., 2007).

Table A3.2.11 Influence of individual site and management factors on predicted wood density for New Zealand planted forest

	Range in predicted density	
Factor affecting wood density	(kg m^{-3})	(% difference)
Temperature: 8°C versus 16°C	359–439	22
Age: 10-year-old versus 30-year-old	380–446	17
C:N ratio: 12 versus 25	384–418	9
Stocking: 200 versus 500 stems ha^{-1}	395–411	4

Note: C:N = carbon:nitrogen.

The stand tending model: New Zealand's plantation forests are intensively managed and, therefore, pruning and thinning provide the majority of the inputs to the dead wood and litter pools. The Forest Carbon Predictor requires silvicultural history inputs to predict changes between biomass pools over time. The information required includes initial stocking, the timing of management events, stocking following each thinning operation and the pruned height and number of stems pruned for each pruning lift. Information on silvicultural events before the plot measurement date is normally gathered from forest owners but sometimes these data are incomplete. A history module has been incorporated into the Forest Carbon Predictor that makes use of existing data to identify potential gaps in the stand history.

Within the history module, assumptions are made to complete the stand history based on field observations, standard management regimes and known silviculture to date (Beets and Kimberley, unpublished). The history module enables reasonable estimates of stand history and, therefore, biomass transfers between pools resulting from past silvicultural events.

The C_Change carbon allocation model is designed to apportion carbon to needles, branches, stems, roots and reproductive parts via growth partitioning functions and is integrated into the Forest Carbon Predictor. Dead wood and litter pools are estimated by accounting for losses to the live pools from natural mortality, disease effects on needle retention, branch and crown mortality and silvicultural management activities, for example, pruning and thinning. Component-specific and temperature-dependent decay functions are used to estimate losses of carbon to the atmosphere (Beets et al., 1999). The Forest Carbon Predictor also takes into account biomass removals during production thinning.

The individual plot yield curves generated by the Forest Carbon Predictor are combined into estimates of above-ground live biomass, below-ground live biomass, dead wood and litter in an area-weighted and age-based carbon yield table for the productive area of each type of planted forest. Plots that are located outside the productive area within the mapped forest boundary are used to provide emission factors for unstocked areas in both post-1989 forest and pre-1990 planted forest (Paul et al., unpublished(f)).

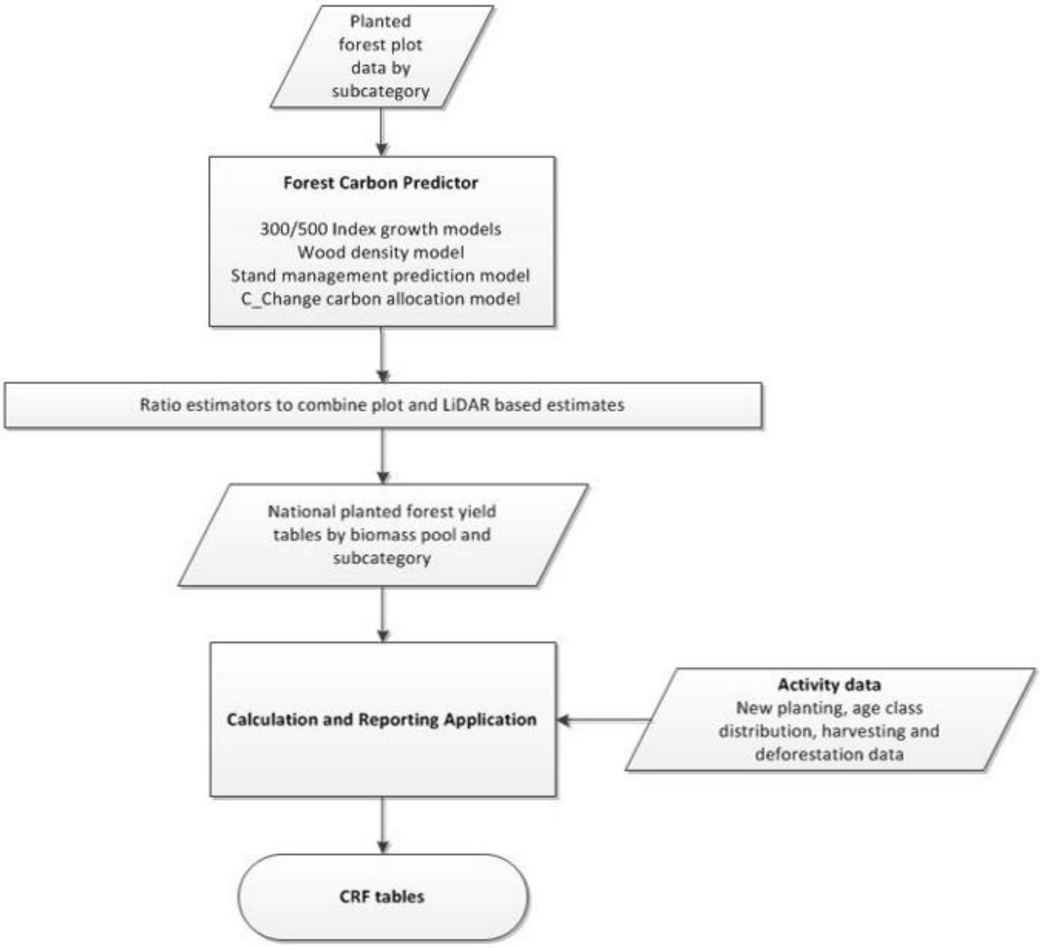
Below-ground biomass is derived from the above-ground biomass estimates. For plantation crop trees, below-ground biomass is assumed to be 15 per cent to 20 per cent of total production, depending on stand age (Beets et al., 1999). The ratio for non-crop trees and shrubs is 25 per cent (Coomes et al., 2002).

The carbon content of the dead wood pool within a rotation is estimated using the Forest Carbon Predictor model as described above. Immediately following harvesting, 30 per cent of the above-ground biomass pool is transferred to the dead wood pool; the other 70 per cent is instantaneously emitted. All material in the dead wood and litter pools is decayed using an empirically derived, temperature-dependent decay profile as described in Garrett et al. (2010).

Yield tables: Mean yield tables are derived from individual plot tables, described below using plot area-weighted averages. Yield values based on the backcast values from the first measurements are used from year 0 to the year of the first measurement. A straight interpolation is used between the first and the second measurement and any subsequent measurements.

From the last measurement onwards the forecasts are based on the most recent measurement to predict the stand yield until age 60 for both post-1989 planted forest and pre-1990 planted forest plots. A further adjustment is made using an imputation method to account for forecasting and backcasting errors. This method applies a greater weighting at yield table ages close to the plot measurement age. The planted forest yield tables used in this submission are given in section A3.2.5 ‘Planted forest yield tables’.

Figure A3.2.9 New Zealand's planted forest inventory modelling process



Note: CRF = common reporting format; LiDAR = Light Detection and Ranging.

For shrubs and non-crop tree species measured within the planted forest plot network, the carbon content is estimated using species-specific allometric equations. These equations estimate carbon content from diameter and height measurements, and wood density by species (Beets et al., 2012a).

Pre-1990 planted forest

Stock change in the productive area of pre-1990 planted forests is estimated using forest type-specific national yield tables. Plots that are located outside the productive area within the mapped forest boundary are used to provide emission factors for unstocked areas of pre-1990 planted forests (Paul et al., unpublished(a)).

A stratification approach has been developed to stratify the data, allowing the modelling of period-dependent yield tables, creating historic and current yield tables based on reporting periods for pre-1990 planted forests (Paul and Wakelin, unpublished). These yield tables better reflect the conditions and productivity during the past. Using the plot measurements described above under the pre-1990 planted forest inventory, a single yield table per plot was developed using:

- the earlier measurement for ages below the first measurement age
- the later measurement for ages above the later measurement age
- an interpolated estimate for the ages between the earlier and later measurements.

For plots that have been measured once, a ratio estimator derived from plots that have been measured twice is applied to the predicted stocks at the missing measurement date (assuming that the correction for possible bias was the same in both strata) (Paul et al., unpublished(a)).

Post-1989 planted forest

In the post-1989 planted forest inventory, circular 0.06 hectare permanent sample plots have been established within forests on a systematic 4-kilometre grid coincident with that used for the pre-1990 natural forest and pre-1990 planted forest inventories (Moore and Goulding, unpublished). Permanent sample plots were selected over temporary sample plots because change over time is more easily analysed when there are multiple measurements of the same plot set (Beets et al., 2011a).

The initial post-1989 planted forest inventory carried out during the winters of 2007 and 2008 at 246 sites consisted of up to four sample plots in a cluster arrangement. The plots were sampled using the methods as described in Payton et al. (unpublished). A second inventory was carried out during the winters of 2011 and 2012 where the centre plot of the earlier established cluster plots was re-measured and additional new plots were established. In total, 342 plots were ground measured from the mapped area of post-1989 planted forest in the second inventory. Importantly, the additional plots in the later inventory addressed a bias in the earlier estimates caused by incomplete sampling of the forest area. This was due to the initial field inventory beginning before the completion of the 2008 land use map. The planted forest inventory shifted from a periodic to a continuous inventory in 2016. The continuous inventory measures around 140 permanent sample plots annually over a five-year re-measurement cycle. The continuous inventory provides annual data on forest management (e.g., harvest age and thinning), natural disturbance and growth that can be incorporated into planted forest carbon stock estimates.

The ground measurements in the post-1989 planted forest inventory are the same as those used in the pre-1990 planted forest inventory described above.

Stock change in the productive area of post-1989 planted forest is estimated using a forest type-specific national yield table approach similar to that described above within pre-1990 planted forest. Plots that are located outside the productive area within the mapped forest boundary are used to provide carbon stock estimates for unstocked areas of post-1989 planted forests (Paul et al., unpublished(d)). It has been demonstrated in the development of the post-1989 forest yield table that forests planted on grassland are more productive than those planted on forest land (Paul et al., unpublished(c)).

To use all plot measurements described above, a single yield table per plot was developed using the estimated carbon stock at each measurement date. An interpolated estimate is used to provide carbon stock at all ages between the measurement dates. The advantage of the interpolation method is that it maintains the actual carbon stock values at individual measurement dates. Individual yield tables are combined as weighted means in a national yield table for the productive area of post-1989 planted forest (Paul et al., unpublished(d)).

New Zealand plantation forests are actively managed, with thinning and pruning activities undertaken early in the rotation. Most of these activities are completed before trees reach the age of 13 years. Thus, the dead wood and litter pools from these management practices gradually increase leading up to this age. After the age of 13 years, when pruning and thinning cease and decay exceeds inputs, these pools decline. Due to the age-class structure of post-1989 forest in New Zealand, this can be seen as a rapid increase in the dead wood and litter pools over consecutive years.

Quality assurance and quality control

Quality-assurance and quality-control activities were conducted throughout the pre-1990 and post-1989 planted and natural forest data capture and processing steps. These activities were associated with the following: inventory design (Beets et al., 2014b; Brack, unpublished; Moore and Goulding, unpublished); acquisition of raw LiDAR data and LiDAR processing; checking eligibility of plots; independent audits of field plot measurements (Beets and Holt, unpublished); auditing data entry; data processing and modelling; regression analysis and double-sampling procedures (Woollens, unpublished); and investigating LiDAR and ground plot colocation (Brack and Broadley, unpublished). These activities are described in detail below.

Pre-1990 natural forest

During the initial measurement of the natural forest plot network (2002–07), 5 per cent of plots measured in the first field season were randomly selected for audit (Beets and Payton, unpublished). In all subsequent field seasons, data collection followed quality-assurance and quality-control processes, as described in Payton et al. (unpublished). This included on-site quality-control checks of field data and review by senior ecologists. Data were collected in the field and recorded by hand on paper field-sheets. The electronic entry of all data has been subject to ongoing quality assurance and quality control, including line-by-line checking of the transcription of all data used in carbon calculations.

During the re-measurement of the plot network from 2009 to 2014, 10 per cent of plots measured were subject to independent audit. For the current re-measurement of the plot network, this has been reduced to 5 per cent of plots measured. This audit involves a partial re-measure of randomly selected plots, and the assessment of measurements against data quality standards as described in the data collection manual (Ministry for the Environment, unpublished). Up until 2020, entry of data into the electronic database from paper-based plot sheets is subject to quality assurance by the Ministry for the Environment. Line-by-line checks were conducted for 10 per cent of all plots, data are now collected electronically so bypass the need for manual data entry. The data are also subject to further checking for measurement and data entry errors before analysis (Paul et al., 2021).

Post-1989 natural forest

As for pre-1990 natural forest, quality control and quality assurance were undertaken at the data collection, entry and analysis stages.

During field data collection in 2012, 10 per cent of plots were subject to an independent field audit. The audit involved randomly selected sites being re-measured by an audit field team, and the assessment of differences between inventory and audit measurements against set data quality standards as set out in Ministry for the Environment (unpublished). Audit results are described in Beets and Holt (unpublished). The same audit process was conducted for the re-measurement of the post-1989 natural forest plot network in 2019. These results are described in Paul and Dowling (unpublished). Similarly to pre-1990 natural forest, entry of data into the electronic database from paper-based plot sheets is subject to quality assurance by the Ministry for the Environment. Line-by-line checks are conducted for 10 per cent of all plots. Further checks for data entry and measurement were also undertaken before the data analysis stage, as described in Beets et al. (unpublished) and Paul et al. (unpublished(b)).

Pre-1990 planted forest and post-1989 planted forest

Of the planted forest inventory plots, 7.5 per cent are randomly audited without the prior knowledge of the inventory teams. Plots are fully and partially re-measured, with feedback supplied no later than one month after measurement, to ensure prompt identification of any data collection errors and/or procedural issues. Differences between the inventory and audit measurements are objectively and quantitatively scored. Measurements that exceed predefined tolerances incur incremental demerit points. Demerit severity depends on the size of error and the type of measurement. Special attention is given to the most influential measurements; for example, tree diameter, tree height and the number of trees in a plot. Plots that fail quality control would have to be re-measured (Beets et al., 2011a, 2012a). Following each inventory season, the data collection manual (Herries et al., unpublished) is revised to clarify any potential sources of error or ambiguity.

The inventory data are pre-processed using Scion's Permanent Sample Plot (PSP) system. The PSP system has been programmed to check for erroneous values over a wide range of attributes. The system automatically identifies fields that do not meet predetermined validation rules so these can be repaired manually before plot data are modelled by the Forest Carbon Predictor. The PSP data validation system and the Forest Carbon Predictor model were independently reviewed by Woollens (unpublished). The Forest Carbon Predictor has been validated in Beets et al. (2011b).

Forest land model validations

LUCAS harvest losses versus Ministry for Primary Industries roundwood statistics

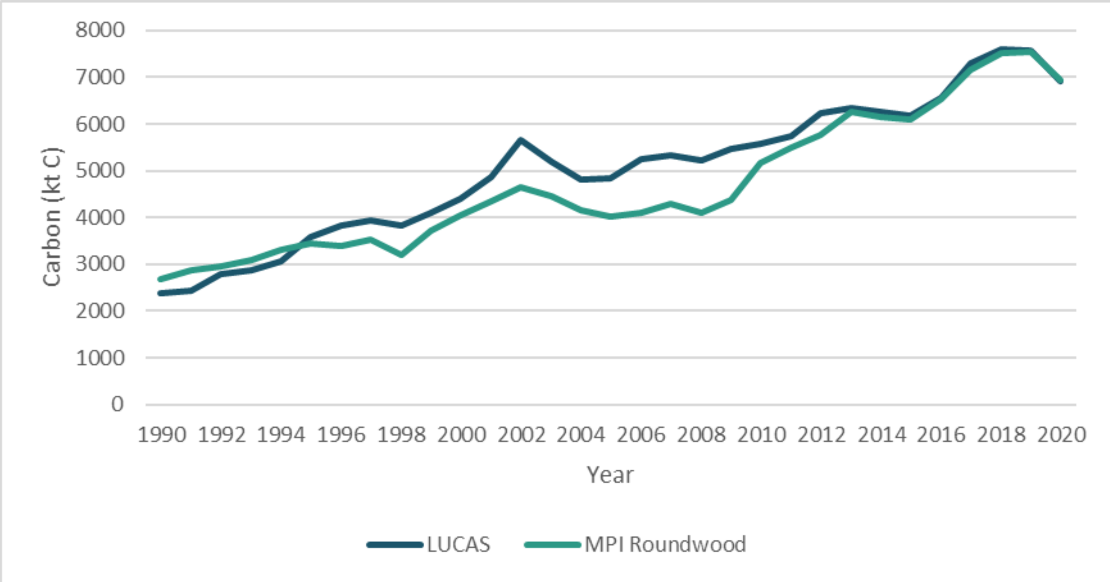
The above-ground biomass estimated to be removed from all planted forest destocking (all harvest and deforestation) was compared to the estimated carbon stored in annual Ministry for Primary Industries roundwood removal statistics (Ministry for Primary Industries, 2021; figure A3.2.10). The Ministry for Primary Industries' roundwood volume was converted to tonnes of carbon based on the carbon fractions used in the harvested wood products model (0.21 t C m^{-3} for coniferous and 0.25 t C m^{-3} for non-coniferous timber).

The results show alignment between the two data sources between 2013 and 2020. This is because roundwood volume is now used to estimate the total destocking area over this period. However, the two data sources deviate from 1990 to 2012. The LUCAS above-ground biomass losses from harvest are greater than those estimated from roundwood volume statistics from 1996 to 2012 and are slightly lower from 1990 to 1994.

Further work is planned to improve the consistency of forest carbon losses of harvest and carbon inputs into the harvested wood products pool within the LUCAS model. To improve this match between harvest losses and roundwood production, input parameters to the planted forest model will need to be adjusted. This could include adjustments to:

1. the harvest area
2. the average harvest age
3. the assumed proportion of above-ground biomass removed as merchantable volume on harvest
4. the yield tables.

Figure A3.2.10 **Comparison of the LUCAS estimate for above-ground biomass removed on planted forest destocking and carbon stored in roundwood production from 1990 to 2020**



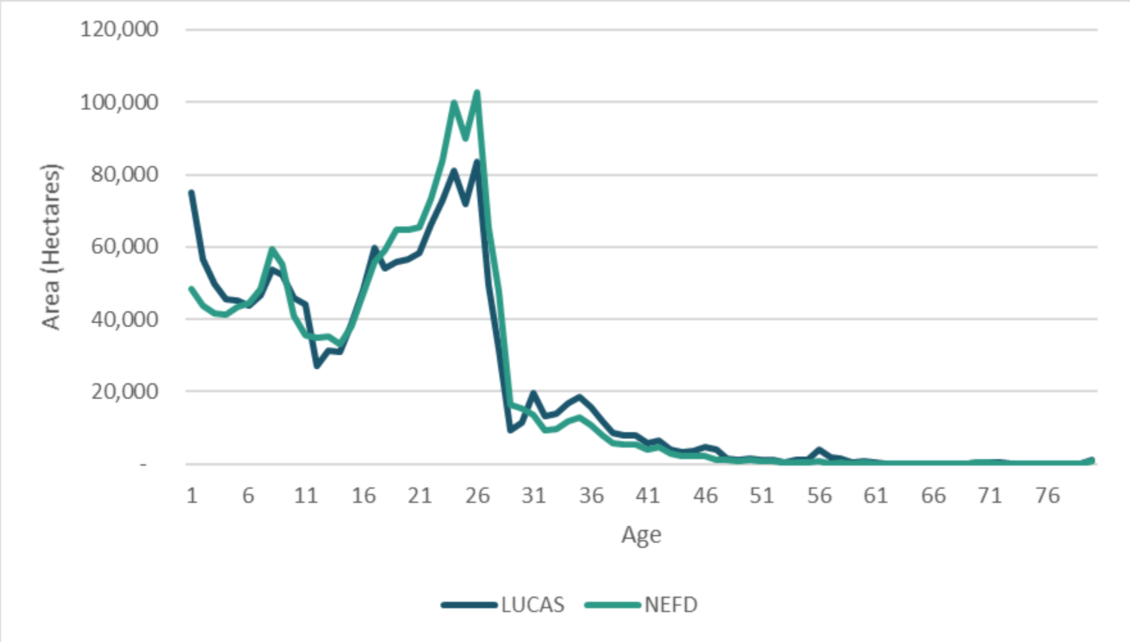
Note: Roundwood production data sourced from Ministry for Primary Industries, 2021. LUCAS = Land Use and Carbon Analysis System; MPI = Ministry for Primary Industries.

Planted forest age profile

The LUCAS net stocked area planted forest age profile was compared to the NEFD planted forest age profile (Ministry for Primary Industries, 2020; figure A3.2.11). Despite the LUCAS forest age profile using NEFD data as an input, notable differences are evident between the two data sources. This is primarily because the NEFD is based on a survey of forest owners, while the LUCAS planted forest age profile at 2020 is based on a modelled simulation of forest activity from 1990 onwards. The LUCAS forest age profile is also influenced by mapped areas of post-1989 and pre-1990 forest and harvest activity from 1990 to 2020. Further details on discrepancies between these two data sources are outlined below.

1. The total mapped area of post-1989 forest is lower than the area of new planting from 1990 onwards reported in the NEFD. As a result, the forest area by age for this forest is scaled down relative to the NEFD estimate. This why the LUCAS area is lower from ages 18 to 30.
2. The LUCAS pre-1990 planted forest age profile from ages 0 to 30 is driven by the reported areas harvested and replanted in the Calculation and Reporting Application (CRA) simulation model (with a one-year lag on replanting between harvest). The LUCAS estimates of harvest and replanting are not consistent with the NEFD replanting estimates, resulting in a difference in the forest age profiles.
3. The LUCAS forest age profile from ages 30 onwards represents forests planted before 1990. The age profile of this forest follows the same pattern as the NEFD data (which they are based on) but report a higher area for each age. This is because the LUCAS area for these age groups is greater than the areas reported in the NEFD and is scaled to the total mapped area of pre-1990 planted forest net stocked area.

Figure A3.2.11 Comparison of the planted forest age profile as estimated from LUCAS net stocked area for all planted forest (post-1989 and pre-1990) and the NEFD age profile as at 2020



Note: The age profile starts age 1 and does not include areas of forest that were planted or harvested and awaiting replanting in 2020. LUCAS = Land Use and Carbon Analysis System; NEFD = National Exotic Forest Description.

LUCAS planted forest inventory plot measurements versus yield table values

The yield tables generated by the Forest Carbon Predictor were validated in Beets et al. (2011b). The results indicated a good match between carbon stock and stock change predicted from the Forest Carbon Predictor by with plot measurements.

A validation was carried out by LUCAS in 2021 on the carbon stock per hectare values of the yield tables used is this inventory submission, as suggested by the expert review team during the review of the 2021 submission. A comparison was made between the yield table carbon stocks and the measured plot values from the 2016 to 2020 forest inventory used to generate them. The yield table values were adjusted down by half a year to be more consistent with the period that each plot was measured. The yield tables were then fitted to the ages of the measured plots, to provide a comparison of carbon stock per hectare estimates of the yield tables and the measured plots.

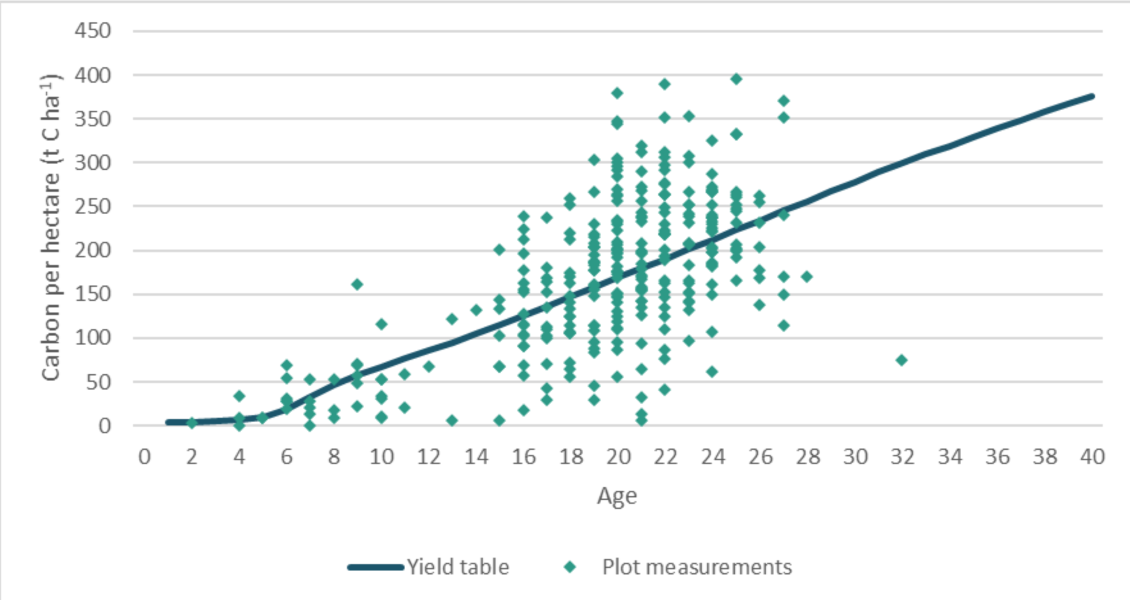
The results of this comparison are shown in table A3.2.12 and figures A3.1.12 to A3.1.13. An area weighted average carbon stock per hectare for each forest type was calculated from plots measured in the 2016 to 2020 planted forest inventory and from adjusted yield table values fitted to the ages of these plots (table A3.2.12). Note that the average carbon stock per hectare of measured plots differs from the results of Paul et al. (unpublished(e)), because these estimates only include plots used to generate the yield tables.

Table A3.2.12 Comparison of the average biomass carbon stock per hectare for each forest type, calculated as the area weighted average of plot measurements and yield table values

	Plots measured in 2016–20 forest inventory			Yield table values fitted to plot age		Difference
Forest type	t C ha^{-1}	95% CI	Number of plots	t C ha^{-1}	95% CI	t C ha^{-1}
Post-1989	168.3	9.5	315	173.4	7.2	–5.1
Pre-1990 – after 1990	96.7	11.0	221	108.7	5.0	–12.0
Pre-1990 – before 1990	252.5	43.9	23	282.3	22.4	–29.8

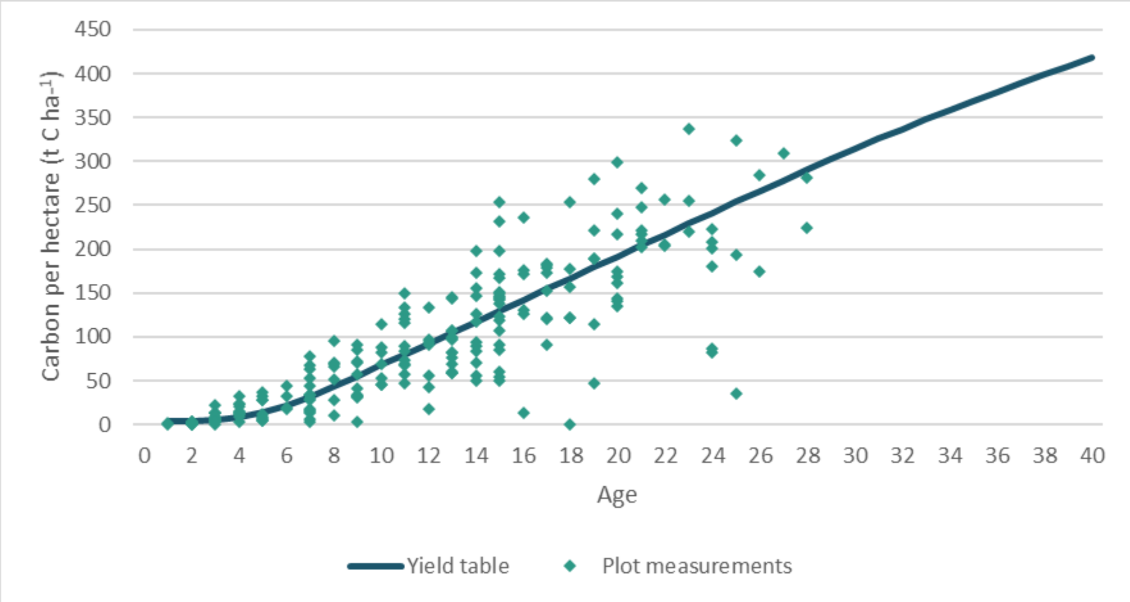
The average carbon stock per hectare of measured plots in post-1989 forest that were used to generate the yield table was 168.3 ± 9.3 t C ha^{-1}. When fitting the adjusted yield table carbon values to the measured plot ages, the average carbon stock per hectare is 173.4 ± 7.2 t C ha^{-1}. On average, the yield table estimates carbon stock per hectare to be 5.1 t C ha^{-1} higher than the measured plot values. This suggests a relatively good fit and is within the average confidence interval (7.2 t C ha) of the yield table.

Figure A3.2.12 Post-1989 planted forest carbon stock by age estimated from the yield table and plots measured in the 2016 to 2020 forest inventory



The average carbon stock per hectare of measured plots in pre-1990 forest planted after 1990 is 96.7 ± 11 t C ha^{-1}. When fitting the adjusted yield table carbon values to the measured plot ages, the average carbon stock per hectare is 108.7 ± 5 t C ha^{-1}. On average, the yield table estimates carbon stock per hectare to be 12 t C ha^{-1} higher than the measured plot values. This suggests the yield table for pre-1990 forest planted after 1990 could be overestimating carbon stocks in this forest type. Figure A3.2.13 indicates this could be partially driven by several low-yield plots aged between 16 and 25 that drag the average carbon stock per hectare down.

Figure A3.2.13 Pre-1990 planted forest planted after 1990 carbon stock by age estimated from the yield table and plots measured in the 2016 to 2020 forest inventory

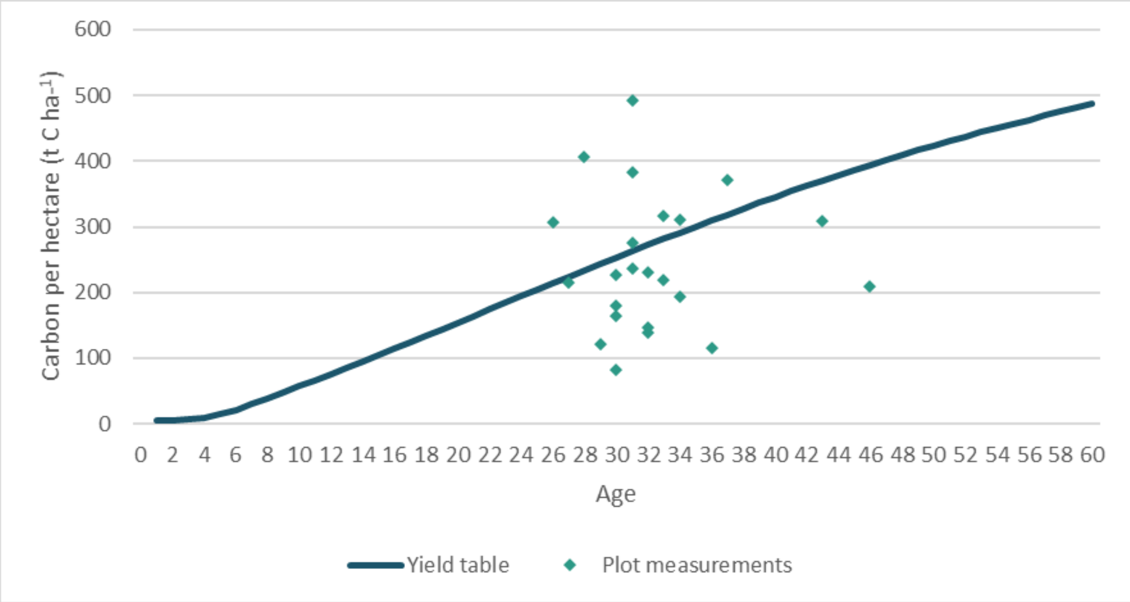


The average carbon stock per hectare of measured plots in pre-1990 forest planted before 1990 is 252.5 ± 44 t C ha^{-1}. When fitting the adjusted yield table carbon values to the measured plot ages, the average carbon stock per hectare is 282.3 ± 22.4 t C ha^{-1}. On average, the yield table estimates carbon stock per hectare to be 29.8 t C ha^{-1} higher than the measured plot values. This suggests the yield table for pre-1990 forest planted after 1990 could also be overestimating the current carbon stocks in this forest type.

However, the large difference between the average yield table values and plots measured in the most recent five-year inventory is likely because the period specific yield tables were estimated from plots that have since been harvested. It is likely that higher yielding plots have been prioritised in harvest and are no longer represented in the 2016 to 2020 forest inventory. Thus, the plots remaining in the 2016 to 2020 forest inventory may be expected to have lower carbon values on average than the yield table that represents all plots planted before 1990.

Analysis and validation of plot measurements to yield table carbon stock values will continue to be undertaken as more data becomes available.

Figure A3.2.14 Pre-1990 planted forest – planted before 1990 – carbon stock by age estimated from the yield table and plots measured in the 2016 to 2020 forest inventory

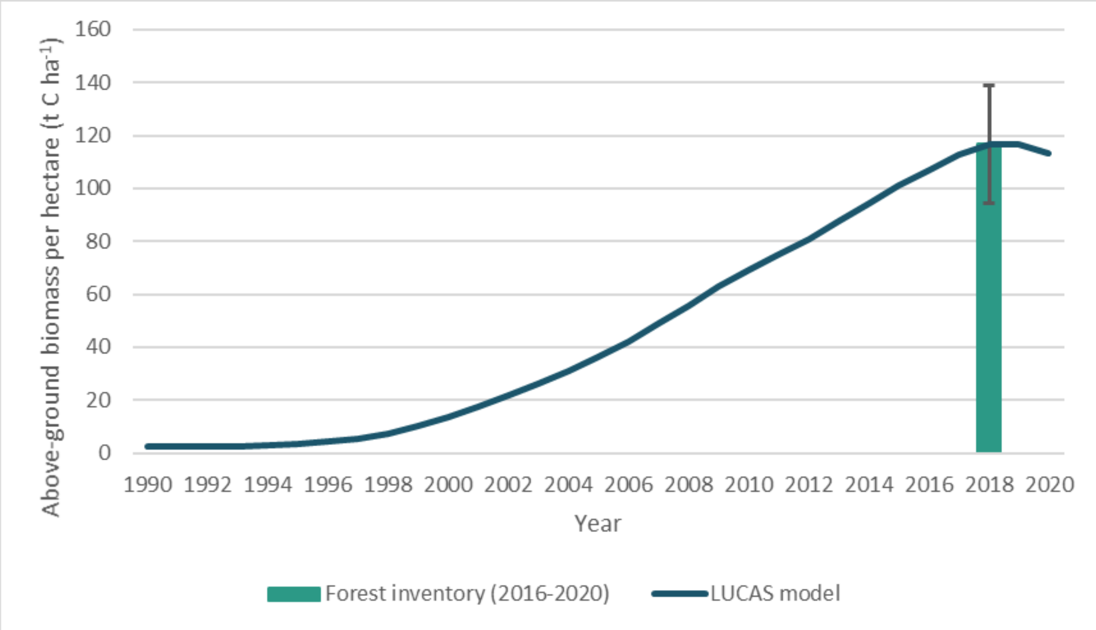


LUCAS planted forest model versus forest inventory measurements

The average above-ground biomass carbon stock per hectare, estimated from the planted forest inventory (Paul et al., unpublished(e)) was compared to the carbon stock per hectare estimated from the LUCAS CRA model.

In post-1989 planted forests, the average above-ground biomass carbon stock per hectare in the 2016 to 2020 forest inventory was 116.7 ± 22.3 t C ha^{-1} (derived from Paul et al., unpublished(e)). This provides an almost exact match to the estimated carbon stock per hectare in 2018 generated from the LUCAS CRA model (116.7 t C ha^{-1}; figure A3.2.15). This suggests the LUCAS CRA model simulation of yield table combined with planting and harvest data provide a reliable estimate of carbon stock and stock change for post-1989 planted forests. It is particularly important to ensure reliability in estimated carbon stocks for post-1989 planted forest, because this represents the total carbon gain since 1990.

Figure A3.2.15 Post-1989 planted forest above-ground biomass carbon per hectare estimated from the forest inventory and LUCAS Calculation and Reporting Application model



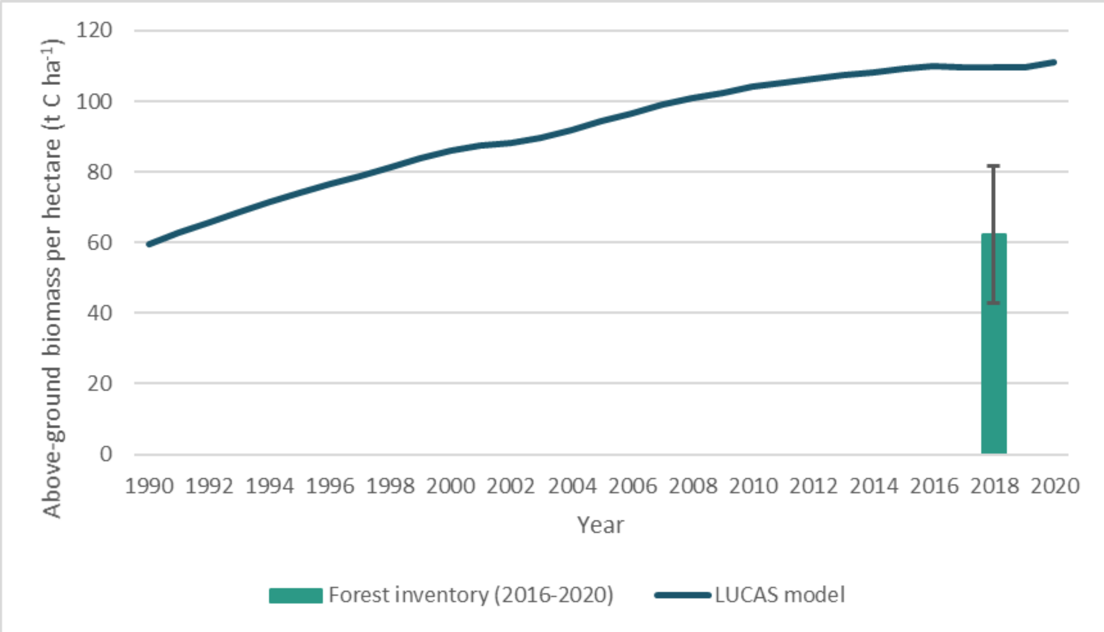
In pre-1990 planted forests, the average above-ground biomass carbon stock per hectare in the 2016 to 2020 forest inventory was 62.3 ± 19.5 t C ha^{-1} (derived from Paul et al., unpublished(e)). This is much lower than the estimated carbon stock per hectare in 2018 generated from the LUCAS CRA model used for this submission (109.6 t C ha^{-1}; figure A3.2.16). This discrepancy raises questions around how well the LUCAS CRA model simulation of yield tables, combined with planting and harvest data, estimates carbon stock and stock change in pre-1990 planted forests.

Several factors may contribute to this discrepancy.

1. The estimates from the forest inventory (Paul et al., unpublished(e)) assume all plots that were too young to measure had a carbon stock value of zero. In contrast, the yield tables have estimated carbon stocks for these younger stands. Because the pre-1990 planted forest has a large area of forest that is recently harvested, this is likely to contribute to higher carbon stock per hectare in estimates in the LUCAS model.
2. A comparison of yield table carbon stocks to plot measurements (table A3.2.12) indicates that the yield tables tend to predict higher carbon stocks than measured plots in pre-1990 planted forest. The difference between yield table and plot measurements is more pronounced in older plots (figures A3.2.13 and A3.2.14).
3. A relatively large area of forest considered to be older than 40 years is captured in the NEFD and thus also in the LUCAS age profile. Additionally, the approach used to calculate the forest age profile results in this area of older forest being scaled up from the NEFD estimate, to meet the total net stocked area estimate (figure A3.2.11). In comparison, a lower proportion of plots in this older age group are detected in the planted forest inventory. It is possible that the area of forest in this age range is overestimated, resulting in higher carbon stock per hectare estimates in the LUCAS model.

Further analysis and validation between plot measurements, yield table values and the CRA model output is planned in future inventory submissions, to ensure reliable estimates of carbon stock and stock change from the LUCAS model.

Figure A3.2.16 Pre-1990 planted forest above-ground biomass carbon per hectare estimated from the forest inventory and LUCAS Calculation and Reporting Application model



Natural forest carbon stock change estimates and yield tables

This section contains the natural forest carbon stock change estimates and yield tables used for this submission.

Table A3.2.13 Pre-1990 natural forest – tall forest carbon stocks by year (tonnes C ha^{-1})[1]

Year	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
1990	145.1	34	44	22.2	245.4
1991	145.1	34	44	22.2	245.4
1992	145.1	34	44	22.2	245.4
1993	145.1	34	44	22.2	245.4
1994	145.1	34	44.1	22.2	245.4
1995	145.1	34	44.1	22.2	245.4
1996	145	34	44.1	22.2	245.4
1997	145	34	44.1	22.2	245.4
1998	145	34	44.1	22.2	245.4
1999	145	34	44.1	22.2	245.3
2000	145	34	44.1	22.2	245.3
2001	145	34	44.1	22.2	245.3
2002	145	34	44.1	22.2	245.3
2003	144.9	34	44.1	22.2	245.3
2004	144.9	34	44.1	22.2	245.3
2005	144.9	34	44.1	22.2	245.3
2006	144.9	34	44.1	22.2	245.3
2007	144.9	34	44.2	22.2	245.3
2008	144.9	34	44.2	22.2	245.2
2009	144.9	34	44.2	22.2	245.2
2010	144.8	34	44.2	22.2	245.2
2011	144.8	34	44.2	22.2	245.2
2012	144.8	34	44.2	22.2	245.2

Year	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
2013	144.8	33.9	44.2	22.2	245.2
2014	144.8	33.9	44.2	22.2	245.2
2015	144.8	33.9	44.2	22.2	245.2
2016	144.8	33.9	44.2	22.2	245.1
2017	144.7	33.9	44.2	22.2	245.1
2018	144.7	33.9	44.2	22.2	245.1
2019	144.7	33.9	44.2	22.2	245.1
2020	144.7	33.9	44.2	22.2	245.1

[1] Data derived from Paul et al., 2021.

Table A3.2.14 Pre-1990 natural forest – regenerating forest carbon stocks by year (tonnes C ha^{-1})[1]

Year	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
1990	34.1	8.2	10.4	9.7	62.3
1991	34.5	8.3	10.3	9.7	62.8
1992	34.8	8.4	10.3	9.7	63.2
1993	35.2	8.5	10.3	9.7	63.6
1994	35.5	8.5	10.3	9.7	64.1
1995	35.9	8.6	10.3	9.7	64.5
1996	36.2	8.7	10.3	9.7	64.9
1997	36.6	8.8	10.3	9.7	65.3
1998	37	8.9	10.3	9.7	65.8
1999	37.3	8.9	10.2	9.7	66.2
2000	37.7	9	10.2	9.7	66.6
2001	38	9.1	10.2	9.7	67
2002	38.4	9.2	10.2	9.7	67.5
2003	38.7	9.3	10.2	9.7	67.9
2004	39.1	9.4	10.2	9.7	68.3
2005	39.5	9.4	10.2	9.7	68.8
2006	39.8	9.5	10.2	9.7	69.2
2007	40.2	9.6	10.2	9.7	69.6
2008	40.5	9.7	10.1	9.7	70
2009	40.9	9.8	10.1	9.7	70.5
2010	41.2	9.9	10.1	9.7	70.9
2011	41.6	9.9	10.1	9.7	71.3
2012	41.9	10	10.1	9.7	71.7
2013	42.3	10.1	10.1	9.7	72.2
2014	42.7	10.2	10.1	9.7	72.6
2015	43	10.3	10.1	9.7	73
2016	43.4	10.4	10	9.7	73.5
2017	43.7	10.4	10	9.7	73.9
2018	44.1	10.5	10	9.7	74.3
2019	44.4	10.6	10	9.7	74.7
2020	44.8	10.7	10	9.7	75.2

[1] Data derived from Paul, et al., 2021.

Table A3.2.15 Post-1989 natural forest yield table (tonnes C ha^{-1})[1]

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
0	1.6	0.4	0.0	0.0	2.0
1	2.5	0.6	0.0	0.0	3.2
2	3.7	0.9	0.0	0.1	4.7
3	5.1	1.3	0.0	0.1	6.5
4	6.6	1.7	0.0	0.1	8.4
5	8.3	2.1	0.0	0.1	10.6
6	10.2	2.6	0.1	0.2	13.0
7	12.2	3.1	0.1	0.2	15.5
8	14.4	3.6	0.1	0.2	18.2
9	16.6	4.2	0.1	0.2	21.1
10	18.9	4.7	0.1	0.3	24.0
11	21.4	5.3	0.1	0.3	27.1
12	23.9	6.0	0.1	0.3	30.2
13	26.4	6.6	0.1	0.4	33.5
14	29.0	7.2	0.1	0.4	36.7
15	31.6	7.9	0.1	0.4	40.0
16	34.2	8.6	0.1	0.4	43.3
17	36.8	9.2	0.1	0.5	46.7
18	39.4	9.9	0.1	0.5	49.9
19	42.0	10.5	0.1	0.5	53.2
20	44.5	11.1	0.1	0.6	56.4
21	47.0	11.8	0.2	0.6	59.5
22	49.4	12.3	0.2	0.6	62.5
23	51.7	12.9	0.2	0.6	65.4
24	53.9	13.5	0.2	0.7	68.2
25	56.0	14.0	0.2	0.7	70.9
26	57.9	14.5	0.2	0.7	73.3
27	59.7	14.9	0.2	0.8	75.6
28	61.4	15.3	0.2	0.8	77.7
29	62.9	15.7	0.2	0.8	79.6
30	64.1	16.0	0.2	0.9	81.3

[1] Yield table source Paul, et al., unpublished(b).

Table A3.2.16 Post-1989 natural forest yield table (tonnes C ha^{-1})[1] (for transitions from grassland with woody biomass)

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
0	9.4	3.1	0.1	0.6	13.1
1	10.2	3.3	0.1	0.6	14.1
2	11.2	3.5	0.1	0.6	15.4
3	12.4	3.8	0.1	0.6	16.9
4	13.8	4.1	0.1	0.6	18.6
5	15.3	4.5	0.1	0.6	20.5
6	16.9	4.8	0.1	0.6	22.5
7	18.7	5.3	0.1	0.6	24.7
8	20.6	5.7	0.1	0.6	27
9	22.5	6.2	0.1	0.6	29.5

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
10	24.6	6.7	0.1	0.6	32
11	26.7	7.2	0.1	0.7	34.7
12	28.9	7.7	0.1	0.7	37.4
13	31.1	8.2	0.1	0.7	40.1
14	33.4	8.7	0.2	0.7	43
15	35.7	9.3	0.2	0.7	45.8
16	37.9	9.8	0.2	0.7	48.6
17	40.2	10.4	0.2	0.7	51.5
18	42.5	10.9	0.2	0.7	54.3
19	44.8	11.4	0.2	0.7	57.1
20	47	12	0.2	0.8	59.9
21	49.1	12.5	0.2	0.8	62.5
22	51.2	13	0.2	0.8	65.1
23	53.2	13.5	0.2	0.8	67.6
24	55.2	13.9	0.2	0.8	70
25	57	14.3	0.2	0.8	72.3
26	58.7	14.7	0.2	0.8	74.4
27	60.3	15.1	0.2	0.8	76.4
28	61.7	15.5	0.2	0.8	78.2
29	63	15.8	0.2	0.9	79.8
30	64.1	16	0.2	0.9	81.3

[1] Yield table source derived from Paul, et al., unpublished(b).

Planted forest yield tables

This section contains the planted forest yield tables used for this submission.

Table A3.2.17 Pre-1990 'planted before 1990' planted forest yield table (tonnes C ha^{-1})[1]

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
0	3.3	0.8	0.26	0	4.36
1	3.44	0.85	0.26	0.01	4.55
2	3.85	0.98	0.26	0.03	5.12
3	5.12	1.4	0.26	0.14	6.92
4	7.89	2.18	0.27	0.45	10.78
5	12.09	3.2	0.35	1.25	16.89
6	17.35	4.41	0.62	2.59	24.96
7	22.58	5.51	1.61	4.5	34.2
8	27.07	6.44	3.36	6.74	43.59
9	32.65	7.62	4.24	8.07	52.58
10	39.45	9.04	4.53	8.65	61.65
11	45.43	10.26	5.97	9.47	71.12
12	52.11	11.62	6.9	9.85	80.48
13	60.3	13.3	6.64	9.65	89.88
14	68.44	14.96	6.78	9.56	99.73
15	76.49	16.61	7.2	9.53	109.81
16	83.65	18.05	8.61	9.66	119.95
17	91.24	19.59	9.46	9.6	129.88
18	99.67	21.32	9.01	9.35	139.33

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
19	108.05	23.04	8.66	9.14	148.89
20	116.99	24.9	8.17	8.8	158.85
21	125.8	26.75	7.89	8.53	168.97
22	134.58	28.61	7.69	8.3	179.17
23	143.44	30.5	7.45	8.06	189.44
24	152.08	32.35	7.42	7.89	199.74
25	160.44	34.16	7.51	7.77	209.87
26	168.57	35.93	7.6	7.64	219.74
27	176.58	37.67	7.63	7.53	229.4
28	184.15	39.31	7.94	7.5	238.89
29	191.65	40.96	8.22	7.46	248.27
30	199.64	42.71	8.04	7.34	257.71
31	207.7	44.5	7.87	7.21	267.27
32	215.59	46.24	7.72	7.1	276.65
33	223.37	47.97	7.58	7	285.9
34	231.15	49.73	7.48	6.89	295.24
35	238.78	51.45	7.46	6.79	304.48
36	246.22	53.16	7.52	6.7	313.59
37	253.54	54.85	7.63	6.61	322.62
38	260.76	56.53	7.77	6.52	331.58
39	267.87	58.2	7.94	6.44	340.45
40	274.87	59.86	8.14	6.37	349.23
41	281.75	61.49	8.36	6.3	357.88
42	288.44	63.08	8.59	6.23	366.33
43	294.92	64.64	8.84	6.16	374.56
44	301.19	66.17	9.1	6.09	382.53
45	307.27	67.66	9.37	6.01	390.3
46	313.19	69.13	9.64	5.93	397.88
47	319	70.58	9.92	5.85	405.33
48	324.69	72.01	10.19	5.76	412.65
49	330.24	73.42	10.47	5.68	419.81
50	335.66	74.8	10.74	5.6	426.8
51	340.96	76.17	11.02	5.52	433.65
52	346.13	77.51	11.28	5.44	440.35
53	351.19	78.83	11.54	5.36	446.91
54	356.14	80.13	11.8	5.28	453.35
55	360.99	81.42	12.05	5.21	459.66
56	365.74	82.68	12.29	5.14	465.85
57	370.4	83.93	12.53	5.07	471.92
58	374.97	85.17	12.75	5	477.89
59	379.46	86.39	12.97	4.93	483.75
60	383.91	87.6	13.19	4.87	489.56

[1] Yield table source derived from Paul et al., unpublished(e).

Table A3.2.18 Pre-1990 'planted 1990 onwards' planted forest yield table (tonnes C ha^{-1})[1]

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
0	2.47	0.61	0.17	0	3.24
1	2.62	0.67	0.17	0.01	3.45
2	3.05	0.8	0.17	0.04	4.04
3	4.4	1.24	0.17	0.14	5.94
4	7.46	2.1	0.18	0.45	10.18
5	12.31	3.27	0.23	1.19	16.99
6	18.72	4.71	0.37	2.42	26.19
7	26.21	6.3	0.68	4.07	37.23
8	34.04	7.91	1.38	6.01	49.33
9	42.02	9.53	2.34	7.82	61.69
10	50.69	11.3	2.88	9.05	73.9
11	59.78	13.14	3.33	9.84	86.07
12	69.08	15.03	3.84	10.36	98.31
13	78.86	17.04	4.09	10.58	110.55
14	88.71	19.06	4.51	10.69	122.95
15	98.9	21.17	4.75	10.65	135.45
16	109.56	23.39	4.64	10.44	148.02
17	120.22	25.62	4.63	10.23	160.68
18	130.68	27.83	4.77	10.03	173.29
19	140.96	30.01	4.98	9.83	185.75
20	151.16	32.21	5.21	9.62	198.18
21	161.27	34.43	5.52	9.43	210.64
22	171.31	36.66	5.91	9.25	223.12
23	181.04	38.84	6.62	9.14	235.63
24	190.62	41.01	7.36	9.05	248.02
25	200.3	43.22	7.86	8.91	260.27
26	209.84	45.42	8.41	8.79	272.44
27	219.24	47.61	9	8.68	284.51
28	228.45	49.78	9.64	8.58	296.44
29	237.5	51.93	10.31	8.49	308.21
30	246.35	54.05	11	8.4	319.79
31	254.97	56.14	11.72	8.32	331.14
32	263.37	58.2	12.45	8.24	342.24
33	271.55	60.23	13.19	8.16	353.11
34	279.51	62.24	13.94	8.07	363.74
35	287.28	64.22	14.69	7.98	374.14
36	294.85	66.17	15.43	7.89	384.32
37	302.24	68.09	16.17	7.81	394.28
38	309.47	70	16.89	7.72	404.05
39	316.55	71.88	17.59	7.63	413.65
40	323.5	73.75	18.29	7.55	423.08
41	330.27	75.58	18.96	7.48	432.28
42	336.83	77.36	19.62	7.4	441.2
43	343.18	79.12	20.25	7.32	449.86
44	349.34	80.85	20.86	7.24	458.26
45	355.32	82.54	21.43	7.16	466.42

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
46	361.12	84.2	21.98	7.07	474.35
47	366.77	85.83	22.5	6.97	482.06
48	372.26	87.44	22.99	6.88	489.55
49	377.6	89.02	23.46	6.79	496.85
50	382.81	90.58	23.89	6.69	503.95
51	387.89	92.11	24.3	6.6	510.88
52	392.86	93.62	24.68	6.51	517.64
53	397.71	95.1	25.03	6.42	524.25
54	402.46	96.57	25.35	6.34	530.71
55	407.12	98.02	25.65	6.25	537.03
56	411.7	99.45	25.93	6.18	543.23
57	416.19	100.87	26.18	6.1	549.32
58	420.6	102.27	26.41	6.03	555.29
59	424.95	103.65	26.62	5.96	561.16
60	429.27	105.03	26.82	5.89	566.98

[1] Yield table source derived from Paul et al., unpublished(e).

Table A3.2.19 Post-1989 planted forest yield table (tonnes C ha^{-1}) [1]

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
0	2.26	0.56	0.21	0	3.03
1	2.44	0.63	0.21	0.01	3.28
2	3.08	0.79	0.21	0.04	4.28
3	4.12	1.32	0.22	0.15	5.3
4	6.47	2.48	0.23	0.41	7.4
5	9.12	3.82	0.25	1.14	12.28
6	17.19	5.16	1.3	2.81	25.24
7	27.41	6.52	2.42	5.22	40.89
8	32.93	7.61	3.7	7.75	52.05
9	37.35	8.47	6.41	10.08	62.43
10	41.67	9.34	8.93	11.65	71.76
11	47.59	10.58	10.06	12.12	80.54
12	55.24	12.17	10.05	11.95	89.59
13	63.91	13.95	9.71	11.61	99.26
14	73	15.8	9.39	11.29	109.44
15	82.28	17.68	9.05	10.96	119.84
16	91.66	19.58	8.74	10.65	130.42
17	101.16	21.52	8.47	10.34	141.2
18	110.76	23.5	8.19	10.03	152.11
19	120.24	25.45	8.02	9.74	163.04
20	129.61	27.4	7.89	9.46	173.88
21	138.87	29.36	7.64	9.16	184.59
22	148.16	31.34	7.28	8.89	195.38
23	157.58	33.36	6.91	8.66	206.39
24	167.01	35.38	6.3	8.46	217.48
25	176.15	37.36	7.13	8.35	228.58
26	185.14	39.33	8.68	8.29	239.64
27	194.19	41.33	7.13	8.1	250.61

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
28	203.14	43.32	4.84	7.82	261.53
29	211.97	45.3	4.72	7.57	272.38
30	220.61	47.25	4.96	7.39	283.09
31	229.06	49.18	4.88	7.25	293.62
32	237.3	51.08	4.82	7.12	303.96
33	245.35	52.96	6.33	7.03	314.11
34	253.22	54.81	8.11	6.99	324.08
35	260.89	56.63	8.57	6.95	333.85
36	268.39	58.43	8.99	6.87	343.43
37	275.72	60.2	9.41	6.79	352.83
38	282.89	61.95	9.83	6.7	362.06
39	289.92	63.69	10.26	6.62	371.15
40	296.83	65.41	10.7	6.53	380.11
41	303.6	67.1	11.13	6.46	388.91
42	310.19	68.75	11.56	6.38	397.5
43	316.6	70.38	11.99	6.31	405.87
44	322.83	71.97	12.41	6.23	414.03
45	328.89	73.54	12.83	6.15	421.97
46	334.77	75.08	13.24	6.07	429.7
47	340.5	76.59	13.64	5.99	437.23
48	346.08	78.08	14.02	5.91	444.58
49	351.52	79.54	14.4	5.82	451.76
50	356.83	80.98	14.76	5.74	458.76
51	362.02	82.4	15.11	5.66	465.61
52	367.09	83.79	15.44	5.58	472.32
53	372.06	85.17	15.76	5.5	478.9
54	376.93	86.53	16.07	5.43	485.34
55	381.71	87.87	16.37	5.35	491.66
56	386.39	89.19	16.65	5.28	497.87
57	390.99	90.5	16.92	5.22	503.97
58	395.52	91.8	17.18	5.15	509.96
59	399.97	93.08	17.42	5.09	515.86
60	404.39	94.35	17.66	5.03	521.71

[1] Yield table source derived from Paul et al., unpublished(e).

A3.2.6 Harvested wood products – exported raw material methodologies

Export market activity data and half-lives

The weighted half-lives applied to sawnwood, wood panels and paper are calculated from the sub-product lifetimes reported by Manley and Evison (Ministry for Primary Industries, 2016) and Wakelin and Kimberley (unpublished). Sub-product half-lives and their proportions for each export market are summarised in tables A3.2.19 to A3.2.21 based on data collected in 2015.

Table A3.2.20 Harvested wood product type, waste and fuel product type, exported volume in 2015 and assumed half-lives for China

Product	Sub-product	Waste/fuel product	Volume (million m^3)	Half-life
PANEL	Appearance plywood		0.1039604	25
PANEL	Construction plywood	Panel (recycled)	1.1435644	2.5
PANEL		Burned	1.1435644	0.5
PANEL	Packaging plywood		0.2079208	3
	Plymill residue	Burned	0.0519802	0
PAPER		Pulp	0.1559406	2
PANEL		Particle board	0.1559406	25
PANEL		MDF	0.1559406	25
SAWN	Plymill core		0.2079208	2
SAWN	Appearance lumber	Remanufactured	0.9356436	35
SAWN	Construction lumber	Panel (recycled)	1.2475248	2.5
		Burned	1.2475248	0.5
SAWN	Packaging lumber		1.1435644	3
	Slabwood	Burned	0.2079208	0
PAPER		Pulp	1.1435644	2
PANEL		Particle board	0.2079208	25
PANEL		MDF	0.2079208	25
	Sawdust	Burned	0.1559406	0
		Pellets	0.519802	0
PANEL		Particle board	0.1559406	25

Table A3.2.21 Harvested wood product type, waste and fuel product type, exported volume in 2015 and assumed half-lives for South Korea

Product	Sub-product	Waste/fuel product	Volume (million m^3)	Half-life
PANEL	Construction plywood	Panel (recycled)	0.1841	25.5
PANEL		Burned	0.0526	0.5
PANEL	Appearance plywood		0.1052	25
PANEL	Plymill residue	MDF	0.2104	25
SAWN	Appearance lumber		0.0263	35
SAWN	Construction lumber	Particle board	0.6838	25.5
SAWN		Burned	0.1841	0.5
SAWN	Packaging lumber		0.3682	3
PANEL	Slabwood	MDF	0.526	25
	Sawdust	Agriculture	0.1841	0
		Burned	0.0526	0
PANEL	MDF		0.0526	25

Table A3.2.22 Harvested wood product type, waste and fuel product type, exported volume in 2015 and assumed half-lives for India

Product	Sub-product	Waste/fuel product	Volume (million m^3)	Half-life
SAWN	Construction lumber		0.432	0.5
SAWN	Packaging lumber	Export	0.352	3
SAWN		Domestic	0.144	0.5
PANEL	Blockboard		0.208	7
	Slabwood	Fuel	0.224	0
PANEL	Sawdust	Particleboard	0.048	25
		Fuel	0.192	0

A3.2.7 Biomass burning detailed methodology

Wildfire

Wildfires induced by natural disturbances (e.g., lightning) are estimated to account for only 0.1 per cent of burning in the *Grassland* and *Forest land* categories in New Zealand (Doherty et al., unpublished; Wakelin, unpublished(b)). No distinction is made between data collected on anthropogenic and natural wildfire events. Given the small incidence of natural-disturbance-induced wildfires in New Zealand, this is not regarded as a significant source of error.

A single weighted biomass density is used to estimate non-CO_2 emissions from wildfire in the *Forest land remaining forest land* category. Wildfire activity data are attributed to each category by the proportion of forest type estimated to be burned over the time series until 2007, then using the actual areas from the wildfire database from that point on. The split before 2007 assumes 87.5 per cent to planted forest and the remainder to natural forest (Wakelin, unpublished(g)). The planted forest activity data are further split into pre-1990 forest and post-1989 forest by the proportion of area each forest type makes up of the total planted forest area. In planted forest, it is assumed that the carbon stock affected by wildfire is equivalent to the carbon stock at the average stand age in each forest type (Wakelin, unpublished(d)). The individual forest type estimates that make up the single weighted figure are derived from the national forest plot network described above in the section 'National forest inventory'.

An estimate for wildfire in *Land converted to grassland* is provided in the inventory. The activity data for wildfire in *Grassland* are attributed to the *Land converted to* and *Land remaining* categories by the proportion each category makes up of the total area.

Controlled burning

Activity data (area of land-use change) for controlled burning for *Forest land* is estimated based on a survey carried out in 2011. Activity data for *Grassland with woody biomass* converted to forest are based on annual land-use changes and an estimate of area burned from the survey of forest owners.

The survey also provided data on the burning of post-harvest slash before restocking. This activity was found to occur mainly as a training exercise for wildfire control or for the clearing of slash heaps on skid sites. The data indicated that 0.8 per cent of restocked area was burned each year in recent years. This estimate was combined with two earlier estimates of controlled burning in planted forest (Forest Industry Training and Education Council, 2005; Robertson, 1998) to provide activity data throughout the time series. It is assumed that 1.6 per cent of restocked area was burned from 1990 to 1997. From 1997, the area burned declines linearly to 0.8 per cent, which is used from 2005 onwards (Wakelin, unpublished(e)).

Activity data are combined with an emission factor derived from the pre-1990 planted forest (planted before 1990) carbon-yield table to estimate emissions from the burning of post-harvest slash (harvest residue) on *Forest land*. The harvest residue is calculated by subtracting the amount of above-ground biomass that is taken off site as logs (70 per cent) from the total above-ground biomass predicted at the age of 28 years (the average harvest age in New Zealand). Below-ground biomass is assumed not to burn. The IPCC default combustion proportion for the burning of harvest residue in non-eucalypt temperate forest (0.62) is applied to estimate emissions from this activity (table 2.6, IPCC, 2006a).

An estimate is provided for burning of post-harvest residues associated with deforestation in the National Inventory Report. No information is available on the extent of burning associated with deforestation in New Zealand. Therefore, it is assumed that 30 per cent of conversions involve burning to clear residues. The IPCC default combustion proportion for the burning of harvest residue in non-eucalypt temperate forest (0.62) is applied to category-specific emission factors to estimate emissions from this activity. The emission factor excludes the proportion of logs taken off site (70 per cent of above-ground biomass) and is taken from the plot-network-derived yield tables by forest type at the average age of harvest in New Zealand.

Carbon dioxide emissions from controlled burning in planted forests are captured at the time of conversion or harvest.

The burning of tussock (*Chionochloa* spp.) grassland occurs in the South Island of New Zealand for pasture renewal and weed control. The amount of burning has been decreasing steadily over the past 50 years, as a result of changes in lease tenure and a reduction in grazing pressure. The tussock burning data are sourced from consents under the Resource Management Act 1991 for activities that occurred between 1990 and 2004. Stats NZ provides these data from 2005 because burning became a permitted activity under the Act in some regions (Thomas et al., 2011).

Current practice in New Zealand is to burn in damp spring conditions, reducing the amount of biomass consumed by fire. To reflect this, a country-specific combustion factor of 0.619 is applied (spring burn carbon fractions averaged across two sites (Payton and Pearce, 2009)) to a country-specific biomass density of 28 (t dm ha^{-1}). The ratio of biomass density to carbon lost upon burning is 0.45 (as cited in Thomas et al., 2011).

An estimate for controlled burning in *Grassland remaining grassland* (*Grassland with woody biomass*) is provided in the inventory. The activity data are sourced from Stats NZ's Agricultural Production survey. The activity data are combined with an emission factor derived from the national forest plot network to estimate non-CO_2 emissions from burning associated with the clearing of vegetation for pasture regeneration. Below-ground biomass is assumed not to burn. The New Zealand-specific default combustion proportion for the burning of shrublands of 0.7 (Wakelin, unpublished(a),(h)) is then applied to estimate emissions from this activity (table 2.6, IPCC, 2006a).

Different emission factors derived from the LUCAS plot network are used for wildfire and controlled burning on *Grassland with woody biomass* in the inventory. The differences are due to the vegetation that is typically converted to forest, which is generally of a lesser stature when compared with other shrubland (Wakelin and Beets, unpublished).

A3.2.8 Uncertainty analysis for the LULUCF sector

All uncertainties associated with activity and emission factors are combined to provide an overall uncertainty estimate for total LULUCF emissions and for each subcategory. For the LULUCF sector, all uncertainties are combined using approach 1 in the IPCC 2006 General Guidance and Reporting: the propagation of error (IPCC, 2006b).

Methods used to calculate uncertainty in Forest land

Uncertainty in net CO_2 emissions from *Forest land* are calculated using several inputs, including uncertainty in mapping, uncertainty in carbon stocks and uncertainty in carbon stock change.

Mineral SOC stocks have an estimated uncertainty of ±7.9 per cent in pre-1990 natural forest, ±12.5 per cent in pre-1990 planted forest and ±10.4 per cent for post-1989 natural and planted forest, as calculated from the Tier 2 method estimates of SOC. Uncertainties in soil carbon stock change are calculated for each specific land use transition (see section A3.2.4, 'Mineral soils').

The uncertainty associated with biomass losses on conversion to *Forest land* is calculated from the carbon stocks in the *from land use* category. Details on the uncertainty associated with biomass gains on conversion to *Forest land* and biomass losses associated with measured carbon stock change losses due to land-use change events are outlined for each forest subcategory below.

Pre-1990 natural forest

The estimates for carbon stock and carbon stock change in pre-1990 natural forests were adapted from Paul et al. (2021). Carbon stocks in 2020 are estimated to be 75.2 ± 14.0 tonnes C ha^{-1} in regenerating natural forest and 245.1 ±15.3 tonnes C ha^{-1} in tall natural forest, with an associated uncertainty at the 95 per cent confidence interval of ± 1,824.76 per cent and ± 6.23 per cent, respectively. The uncertainty associated with carbon stock estimates for the current reporting year were propagated through time using equation 3.2 from IPCC General Guidance and Reporting (IPCC, 2006b). These estimates of carbon stock per hectare are used as emission factors to calculate emissions for land converted from pre-1990 natural forest.

It is possible that the average carbon stock per hectare estimates for tall and regenerating forest, across the entire pre-1990 natural forest estate, are not representative of the forest that has actually been deforested. Consequently, there is additional uncertainty in the estimate of carbon losses from the deforestation of pre-1990 natural forest, due to a potential lack of representativeness in the data. To account for this potential lack of representativeness in the data, expert judgement was made to add an additional component of 20.0 per cent uncertainty to the uncertainty associated with carbon stocks, to provide an overall uncertainty for carbon losses on deforestation.

Carbon stock change was estimated to be 0.43 ± 0.51 tonnes C ha^{-1} yr^{-1} in regenerating natural forest and –0.01 ± 0.2 tonnes C ha^{-1} yr^{-1} for tall natural forest, with an associated uncertainty at the 95 per cent confidence interval of ±119.6 per cent and ±1,678.6 per cent, respectively. The uncertainty in carbon stock change is applied to carbon gains or losses within the pre-1990 natural forest category. Further information on the inputs used to calculate uncertainty associated with pre-1990 natural forest is outlined in table A3.2.23.

Table A3.2.23 Uncertainty in New Zealand's 2020 carbon estimates from pre-1990 natural forest (including land in transition)

Variable	Uncertainty at a 95% confidence interval (%)
Activity data	
Uncertainty in land area	±5.0
Emission factors	
Uncertainty in tall forest biomass carbon stocks	±20.9
Uncertainty in regenerating forest biomass carbon stocks	±27.3
Uncertainty in tall forest biomass carbon change	±1,678.6
Uncertainty in regenerating forest biomass carbon change	±119.6
Uncertainty in soil carbon stocks	±7.9
Uncertainty introduced into net emissions for LULUCF	**±15.5**

Note: Land area includes land in transition in 2020. The activity data and combined emission factor uncertainty are weighted values and have been calculated using equations 3.1 and 3.2 from IPCC General Guidance and Reporting (IPCC, 2006b).

Post-1989 natural forest

The average carbon stock per hectare post-1989 natural forest is estimated to be 38.55 ± 10.23 tonnes C ha^{-1} in 2020, with an associated uncertainty of ±27.5 per cent. The average carbon stock change per hectare in post-1989 natural forest is estimated to be 2.48 ± 1.1 tonnes C ha^{-1} yr^{-1}, with an associated uncertainty of ±27.5 per cent. The uncertainty in carbon stocks is applied to losses from deforestation, while the uncertainty in carbon stock change is applied to carbon gains from forest growth. The uncertainty in the estimates of post-1989 natural forest for the 2022 submission is provided in table A3.2.24.

Table A3.2.24 Uncertainty in New Zealand's 2020 carbon estimates from post-1989 natural forest (including land in transition)

Variable	Uncertainty at a 95% confidence interval (%)
Activity data	
Uncertainty in land area	±8.0
Emission factors	
Uncertainty in biomass carbon stocks (losses)	±27.0
Uncertainty in biomass carbon stock change (gains)	±44.8
Uncertainty in soil carbon stocks	±10.4
Uncertainty introduced into net emissions for LULUCF	**±1.0**

Note: Land area includes land in transition in 2020. The activity data and combined emission factor uncertainty are weighted values and have been calculated using equations 3.1 and 3.2 from IPCC General Guidance and Reporting (IPCC, 2006b).

Pre-1990 planted forest

The uncertainty in carbon losses applied to New Zealand's pre-1990 forest biomass carbon stocks is ±21.0 per cent at the 95 per cent confidence interval, while the uncertainty in carbon stock change (carbon gains) is ±11.4 per cent (see table A3.2.25). The uncertainty in carbon stocks is applied to carbon losses that occur from harvesting and deforestation and the uncertainty in carbon stock change applies to carbon gains from forest growth. These uncertainty estimates take into account the area weighted uncertainty in carbon stocks for each age in the yield table (Paul and Wakelin, unpublished) and the associated uncertainty in estimating the forest age profile and harvest age profile.

The uncertainty in the carbon estimates of pre-1990 planted forest for the 2020 Inventory submission is provided in table A3.2.25.

Table A3.2.25 Uncertainty in New Zealand's 2020 carbon estimates from pre-1990 planted forest (including land in transition)

Variable	Uncertainty at a 95% confidence interval (%)
Activity data	
Uncertainty in land area	±5.0
Emission factors	
Uncertainty in planted forest biomass carbon stocks (losses)	±21.0
Uncertainty in planted forest biomass carbon stock change (gains)	±11.4
Uncertainty in unstocked forest biomass carbon stocks	±146.0
Uncertainty in riparian forest biomass carbon stocks	±75.0
Uncertainty in soil carbon stocks	±12.3
Uncertainty introduced into net emissions for LULUCF	**±48.3**

Note: Land area includes land in transition in 2020. The activity data and combined emission factor uncertainty are weighted values and have been calculated using equations 3.1 and 3.2 from IPCC General Guidance and Reporting (IPCC, 2006b).

Post-1989 planted forest

The uncertainty in carbon losses applied to New Zealand's post-1989 planted forest biomass carbon stocks is ±20.5 per cent, while the uncertainty in carbon stock change (carbon gains) is ±8.9 per cent (see table A3.2.26). The uncertainty in carbon stocks is applied to carbon losses from harvesting and deforestation and the uncertainty in carbon stock change applies to carbon gains from forest growth. These uncertainty estimates take into account the area weighted uncertainty in carbon stocks for each age in the yield table (Paul et al., unpublished(d)) and the associated uncertainty in estimating the forest age profile and harvest age profile.

The uncertainty in the estimates of post-1989 planted forest for the 2020 Inventory submission is provided in table A3.2.26.

Table A3.2.26 Uncertainty in New Zealand's 2020 carbon estimates from post-1989 planted forest (including land in transition)

Variable	Uncertainty at a 95% confidence interval (%)
Activity data	
Uncertainty in land area	±8.0
Emission factors	
Uncertainty in planted forest biomass carbon stocks (losses)	±20.5
Uncertainty in planted forest biomass carbon stock change (gains)	±8.9
Uncertainty in unstocked forest biomass carbon stocks	±72.0
Uncertainty in riparian forest biomass carbon stocks	±75.0
Uncertainty in soil carbon stocks	±10.4
Uncertainty introduced into net emissions for LULUCF	±14.5

Note: Land area includes land in transition in 2020. The activity data and combined emission factor uncertainty are weighted values and have been calculated using equations 3.1 and 3.2 from IPCC General Guidance and Reporting (IPCC, 2006b).

Methods used to calculate uncertainty in Cropland

The uncertainty in mapping *Cropland* is ±8.0 per cent (see table A3.2.27). Further details are given in Dymond et al. (2008).

New Zealand uses IPCC default values for biomass accumulation in annual cropland. For perennial cropland, a New Zealand-specific emission factor is used (Davis and Wakelin, unpublished). Because the perennial and annual cropland emission factors are based on only a limited number of biomass studies, the uncertainty in these figures is estimated as ±75.0 per cent (table 5.9, IPCC, 2006a). The uncertainty associated with biomass losses on conversion to *Cropland* is calculated from the carbon stocks in the *from land use* category. Mineral soil organic carbon stocks have an estimated uncertainty of ±9.7 per cent in annual cropland and ±14.1 per cent in perennial cropland, as calculated from the Tier 2 method estimates of SOC (see table A3.2.27). Uncertainties in soil carbon stock change are calculated for each specific land use transition (section A3.2.4, 'Mineral soils').

For organic soils, New Zealand uses IPCC default values for annual and perennial cropland. The uncertainty associated with the IPCC default values is 90 per cent (based on table 2.3, IPCC, 2006a).

As shown in table A3.2.27, while uncertainty in activity data is low, the uncertainty in the IPCC default variables dominates the overall uncertainty in the estimate provided by New Zealand.

Table A3.2.27 Uncertainty in New Zealand's 2020 *Cropland* carbon estimates (including land in transition)

	Uncertainty at a 95% confidence interval	
	Annual cropland (%)	**Perennial cropland (%)**
Activity data		
Uncertainty in land area	±8.0	±8.0
Emission factors		
Uncertainty in biomass carbon stocks	±75.0	±75.0
Uncertainty in mineral soil carbon stocks	±9.7	±14.1
Uncertainty introduced into net emissions for LULUCF	**±1.1**	**±0.4**

Methods used to calculate uncertainty in Grassland

The uncertainty in mapping *Grassland* is ±8.0 per cent for *High and Low producing grassland* and ±83.0 per cent for *Grassland with woody biomass* (table A3.2.28).

New Zealand uses IPCC default values for biomass accumulation in high producing and low producing grassland. The uncertainty in these figures is given as ±75.0 per cent (table 6.4, IPCC, 2006a). A New Zealand-specific value derived from the LUCAS national forest plot network is used for biomass accumulation in *Grassland with woody biomass*. Due to the uncertainty in this estimate, the IPCC default value of ±75.0 is also applied to G*rassland with woody biomass*. The uncertainty associated with biomass losses on conversion to *Grassland* is calculated from the carbon stocks in the *from land use* category.

Mineral SOC stocks have an estimated uncertainty of ±5.8 per cent in high producing grassland and ±7.3 per cent for both low producing grassland and *Grassland with woody biomass*, as calculated from the Tier 2 method estimates of SOC (see table A3.2.28). Uncertainties in soil carbon stock change are calculated for each specific land use transition (section A3.2.4, 'Mineral soils').

For organic soils, New Zealand uses IPCC default values for annual and perennial cropland. The uncertainty associated with the IPCC default values is ±90.0 per cent (table 2.3, IPCC, 2006a).

Table A3.2.28 Uncertainty in New Zealand's 2020 carbon estimates for the *Grassland* category (including land in transition)

	Uncertainty at a 95% confidence interval		
Land use	**High producing (%)**	**Low producing (%)**	**With woody biomass (%)**
Activity data			
Uncertainty in land area	±8.0	±8.0	±83.0
Emission factors			
Uncertainty in biomass carbon stocks	±75.0	±75.0	±75.0
Uncertainty in soil carbon stocks	±5.8	±7.3	±7.3
Uncertainty introduced into net emissions for LULUCF	**±4.8**	**±0.5**	**±0.7**

Note: Uncertainty in biomass carbon stocks for *Grassland with woody biomass* is estimated using the IPCC default uncertainty value because an independent estimate of uncertainty for this category is not available.

Methods used to calculate uncertainty in Wetlands

The uncertainty in mapping *Wetlands* is ±33.0 per cent (see table A3.2.29).

The uncertainty associated with biomass losses on conversion to *Wetlands* is calculated from the carbon stocks in the *from land use* category. There is assumed to be no gain in carbon biomass on conversion to *Wetlands.*

The uncertainty for mineral SOC stocks in vegetated wetlands is ±12.3 per cent. An estimated uncertainty of ±90 per is used for mineral SOC stocks in open water wetlands. Uncertainties in soil carbon stock change on conversion to and from vegetated wetland are calculated for each specific land use transition (section A3.2.4, 'Mineral soils'). An estimated uncertainty of ±100.0 per cent is applied to all land use conversion to and from open water wetlands (apart from *Other land*, which applies a higher uncertainty, see section A3.2.4, 'Mineral soils').

The uncertainty in the emission factor for peat extracted for horticultural use is ±90.0 per cent, the default IPCC value provided in the 2006 IPCC Guidelines (IPCC, 2006a).

Because emissions from *Wetlands* are very small, the uncertainty introduced into the total net emissions for LULUCF is also very small.

Table A3.2.29 Uncertainty in New Zealand's 2020 carbon estimates for the *Wetlands* category (including land in transition)

Variable	Uncertainty at a 95% confidence interval	
Land use	**Wetlands – vegetated (%)**	**Wetlands – open water (%)**
Activity data		
Uncertainty in land area	±33.0	±33.0
Emission factors		
Uncertainty in biomass carbon stocks	NA	NA
Uncertainty in mineral soil carbon stocks	±12.3	±90.0
Uncertainty in organic soil carbon stocks (on-site CO_2 emissions from peat extraction)	±90.0	NA
Uncertainty introduced into net emissions for LULUCF	**±0.0**	**±0.0**

Note: NA = not applicable. The activity data and combined emission factor uncertainty are weighted values and have been calculated using equation 3.2 from IPCC General Guidance and Reporting (IPCC, 2006b).

Methods used to calculate uncertainty in Settlements

The uncertainty in mapping *Settlements* is ±22.0 per cent (see table A3.2.30).

The uncertainty associated with biomass losses on conversion to *Settlements* is calculated from the carbon stocks in the *from land use* category. There is assumed to be no gain in carbon biomass on conversion to *Settlements.*

Soil organic carbon stocks have an estimated uncertainty of ±95.0 per cent, with a soil carbon stock change from all conversions to and from settlements having an uncertainty of ±100.0 per cent (apart from *Other land*, which applies a higher uncertainty, section A3.2.4, 'Mineral soils').

Table A3.2.30 Uncertainty in New Zealand's 2020 carbon estimates for the *Settlements* category (including land in transition)

Variable	Uncertainty at a 95% confidence interval (%)
Activity data	
Uncertainty in land area	±22.0
Emission factors	
Uncertainty in biomass carbon stocks	NA
Uncertainty in soil carbon stocks	±95.0
Uncertainty introduced into net emissions for LULUCF	**±0.3**

Note: NA = not applicable. The activity data and combined emission factor uncertainty are weighted values and have been calculated using equation 3.2 from IPCC General Guidance and Reporting (IPCC, 2006b).

Methods used to calculate uncertainty in Other land

The uncertainty associated with biomass losses on conversion to *Other land* is calculated from the carbon stocks in the *from land use* category. There is assumed to be no gain in carbon biomass on conversion to *Other land.*

Soil mineral organic carbon stocks have an uncertainty ±70.7, as calculated from the Tier 2 method estimates of SOC (see table A3.2.31). Uncertainties in soil carbon stock change on conversion to and from *Other land* are calculated for each specific land use transition (section A3.2.4, 'Mineral soils').

Table A3.2.31 Uncertainty in New Zealand's 2020 carbon estimates for the land use category *Other land* (including land in transition)

Variable	Uncertainty at a 95% confidence interval (%)
Activity data	
Uncertainty in land area	±22.0
Emission factors	
Uncertainty in biomass carbon stocks	NA
Uncertainty in soil carbon stocks	±70.7
Uncertainty introduced into net emissions for LULUCF	**±0.1**

Note: NA = not applicable. The activity data and combined emission factor uncertainty are weighted values and have been calculated using equation 3.2 from IPCC General Guidance and Reporting (IPCC, 2006b).

Methods used to calculate uncertainty in Harvested wood products

Uncertainty in the *Harvested wood products* estimates is introduced by activity data, conversion factors and decay parameters.

Additions to the *Harvested wood products* carbon pool are calculated by multiplying wood product production volume or weight by product-specific wood density and carbon fractions. Uncertainties for these factors can be combined using approach 1 for combining uncertainties (IPCC, 2006b).

Losses from the *Harvested wood products* pool are estimated using first order decay functions, based on k factors (discard rates) derived from each product's assumed half-life. The same rule for combining uncertainties cannot be used because the k factor is not multiplied by the other factors.

For *Harvested wood product* exports, the following parameters are considered in the uncertainty calculation:

- uncertainty in export log production
- uncertainty in allocation to export market
- uncertainty in mill conversion to products
- uncertainty in wood density
- uncertainty in carbon content.

The *Harvested wood products* category provides the second-greatest contribution to uncertainty in the LULUCF sector. This is driven by large removals because carbon in harvested timber is transferred to this pool and the high uncertainty associated with the end-use and discard rates of New Zealand wood. Uncertainty limits for *Harvested wood products* data and parameters are given in table A3.2.32. Uncertainty in New Zealand's 2020 carbon estimates from emissions associated with *Harvested wood products* is provided in table A3.2.33.

Table A3.2.32 Uncertainty in *Harvested wood products* data and parameters

Parameter	Per cent uncertainty	Origin
Harvested wood products production, import and export data	±15.0	IPCC default (table 12.6, IPCC, 2006a)
Product volume to weight factors	±10.0	Country specific (Wakelin et al., 2020)
Oven dry product weight to carbon weight	±5.0	Country specific (Wakelin et al., 2020)
Discard rate, domestic	±50.0	Country specific (Wakelin et al., 2020)
Discard rate, export	±90.0	Country specific (Wakelin, unpublished(f))

Table A3.2.33 Uncertainty in New Zealand's 2020 carbon estimates from emissions associated with *Harvested wood products*

Variable	Uncertainty at a 95% confidence interval (%)
Activity data	
Uncertainty in activity data	±15.0
Emission factors	
Domestic production	±51.2
Export raw materials	±90.7
Total domestically milled and exported products uncertainty	±67.4
Uncertainty introduced into net emissions for LULUCF	**±20.0**

Methods used to calculate uncertainty for nitrous oxide emissions from soils

Uncertainties for emission factors for direct nitrous oxide (N_2O) emissions associated with nitrogen drainage as well as indirect N_2O emissions from leaching and runoff, are sourced from chapter 11 of the IPCC 2006 Guidelines (IPCC, 2006a). Tables 11.1 and 11.3 of the 2006 IPCC Guidelines give an uncertainty range. The relative uncertainty for these ranges is then calculated using the approach for dealing with asymmetric uncertainties, as described by equation 3.3, chapter 3 of the IPCC General Guidance and Reporting (IPCC, 2006b). For N_2O emissions associated with nitrogen mineralisation, an uncertainty of ±80.0 per cent is applied. Uncertainty associated with the variable used to calculate N_2O emissions from land-use change is summarised in table A3.2.34.

Table A3.2.34 Uncertainty in New Zealand's 2020 estimates from nitrous oxide (N_2O) emissions associated with land-use change

Source	Uncertainty at a 95% confidence interval (%)
Direct N_2O emissions from nitrogen mineralisation	
Activity data	±8.0
Soil carbon	±28.0
C:N ratio	±15.0
N_2O emission factor	±80.0
Direct N_2O emissions from drainage	
Activity data	±33.0
N_2O emission factor	±80.0
Indirect N_2O emissions from leaching and runoff	
Activity data	±8.0
N_2O emission factor	±75.0
Fraction of leaching	**±56.0**
Uncertainty introduced into net emissions for LULUCF	**±0.8**

Note: C:N = carbon:nitrogen.

Disaggregated uncertainty analysis for the LULUCF sector

This section contains the disaggregated uncertainty analysis for the LULUCF sector. This additional information has been provided as a result of the review of New Zealand's 2010 inventory (2012 submission). One of the recommendations of the review was that New Zealand provides "a detailed disaggregated assessment of uncertainty, as well as the aggregated uncertainty associated with the LULUCF sector, consistent with the Intergovernmental Panel on Climate Change (IPCC) good practice guidance for LULUCF". This information is provided in table A3.2.35.

Table A3.2.35 Uncertainty analysis for the LULUCF sector

IPCC category	Gas	1990 emissions or removals (kt CO_2-e)	2020 emissions or removals (kt CO_2-e)	Activity data uncertainty (%)	Emission factor / estimation parameter uncertainty (biomass) (%)	Combined uncertainty (%)	Contribution to variance by category in 2020	Type A sensitivity (%)	Type B sensitivity (%)	Uncertainty in trend in LULUCF emissions introduced by emission factor/ estimation parameter uncertainty (%)	Uncertainty in trend in LULUCF emissions introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total LULUCF emissions (%)
Pre-1990 natural forest	CO_2	–1,375.1	–1,372.3	0.0	263.1	263.1	0.024	0.6	6.5	1.7	0.0	0.0
Pre-1990 planted forest	CO_2	–19,077.0	–7,713.8	0.0	146.1	146.1	0.234	61.8	36.3	90.3	0.0	81.5
Post-1989 planted forest	CO_2	148.5	–10,210.2	0.0	33.0	33.0	0.021	48.9	48.1	16.1	0.0	2.6
Post-1989 natural forest	CO_2	3.8	–687.0	0.0	35.4	35.4	0.000	3.3	3.2	1.2	0.0	0.0
Cropland perennial	CO_2	125.9	65.5	0.0	142.4	142.4	0.000	0.3	0.3	0.5	0.0	0.0
Cropland annual	CO_2	342.8	310.1	0.0	79.9	79.9	0.000	0.3	1.5	0.2	0.0	0.0
Grassland low producing	CO_2	127.0	1,720.2	0.0	65.0	65.0	0.002	7.4	8.1	4.8	0.0	0.2
Grassland high producing	CO_2	413.9	517.4	0.0	22.0	22.0	0.000	0.3	2.4	0.1	0.0	0.0
Grassland with woody biomass	CO_2	69.0	286.9	0.0	54.4	54.4	0.000	1.0	1.4	0.5	0.0	0.0
Wetlands – open water	CO_2	–20.0	–2.8	0.0	169.4	169.4	0.000	0.1	0.0	0.2	0.0	0.0
Wetlands – vegetive non-forest	CO_2	0.2	–1.7	0.0	74.4	74.4	0.000	0.0	0.0	0.0	0.0	0.0
Wetlands – vegetive non-forest – peat extraction	CO_2	9.2	17.9	0.0	18.9	18.9	0.000	0.0	0.1	0.0	0.0	0.0
Settlements	CO_2	75.4	124.1	0.0	61.6	61.6	0.000	0.2	0.6	0.1	0.0	0.0
Other land	CO_2	13.5	114.3	0.0	23.0	23.0	0.000	0.5	0.5	0.1	0.0	0.0
Harvested wood products	CO_2	–2,481.2	–6,834.6	0.0	68.2	68.2	0.040	19.3	32.2	13.2	0.0	1.7
Direct N_2O emissions from N mineralisation/immobilisation	N_2O	181.5	78.8	8.0	86.0	86.4	0.000	0.6	0.4	0.5	0.1	0.0
Direct N_2O emissions from drainage and rewetting	N_2O	78.0	123.8	33.0	80.0	86.5	0.000	0.2	0.6	0.1	0.1	0.0

IPCC category	Gas	1990 emissions or removals (kt CO_2-e)	2020 emissions or removals (kt CO_2-e)	Activity data uncertainty (%)	Emission factor / estimation parameter uncertainty (biomass) (%)	Combined uncertainty (%)	Contribution to variance by category in 2020	Type A sensitivity (%)	Type B sensitivity (%)	Uncertainty in trend in LULUCF emissions introduced by emission factor/ estimation parameter uncertainty (%)	Uncertainty in trend in LULUCF emissions introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total LULUCF emissions (%)
Indirect N_2O emissions from leaching and runoff	N_2O	40.8	17.7	8.0	127.3	127.5	0.000	0.1	0.1	0.2	0.0	0.0
N_2O emissions from biomass burning	N_2O	25.9	51.0	30.0	41.6	51.3	0.000	0.1	0.2	0.0	0.0	0.0
CH_4 emissions from biomass burning	CH_4	68.7	81.7	30.0	41.6	51.3	0.000	0.0	0.4	0.0	0.0	0.0
Total		**–21,229.4**	**–23,313.25**			**Total uncertainty (%)**	**56.7**				**Total uncertainty in trend (%)**	**92.8**

A3.2.9 LUCAS data management system

The LUCAS data management system stores, manages and archives data for international greenhouse gas reporting for the LULUCF sector. This system is used for managing the land use spatial databases, plot and reference data, and for combining the two sets of data to calculate the numbers required for reporting under the Convention and the Kyoto Protocol (see figure A3.2.17).

The data collected is stored and manipulated within three systems: the Geospatial System, the Gateway, and the CRA.

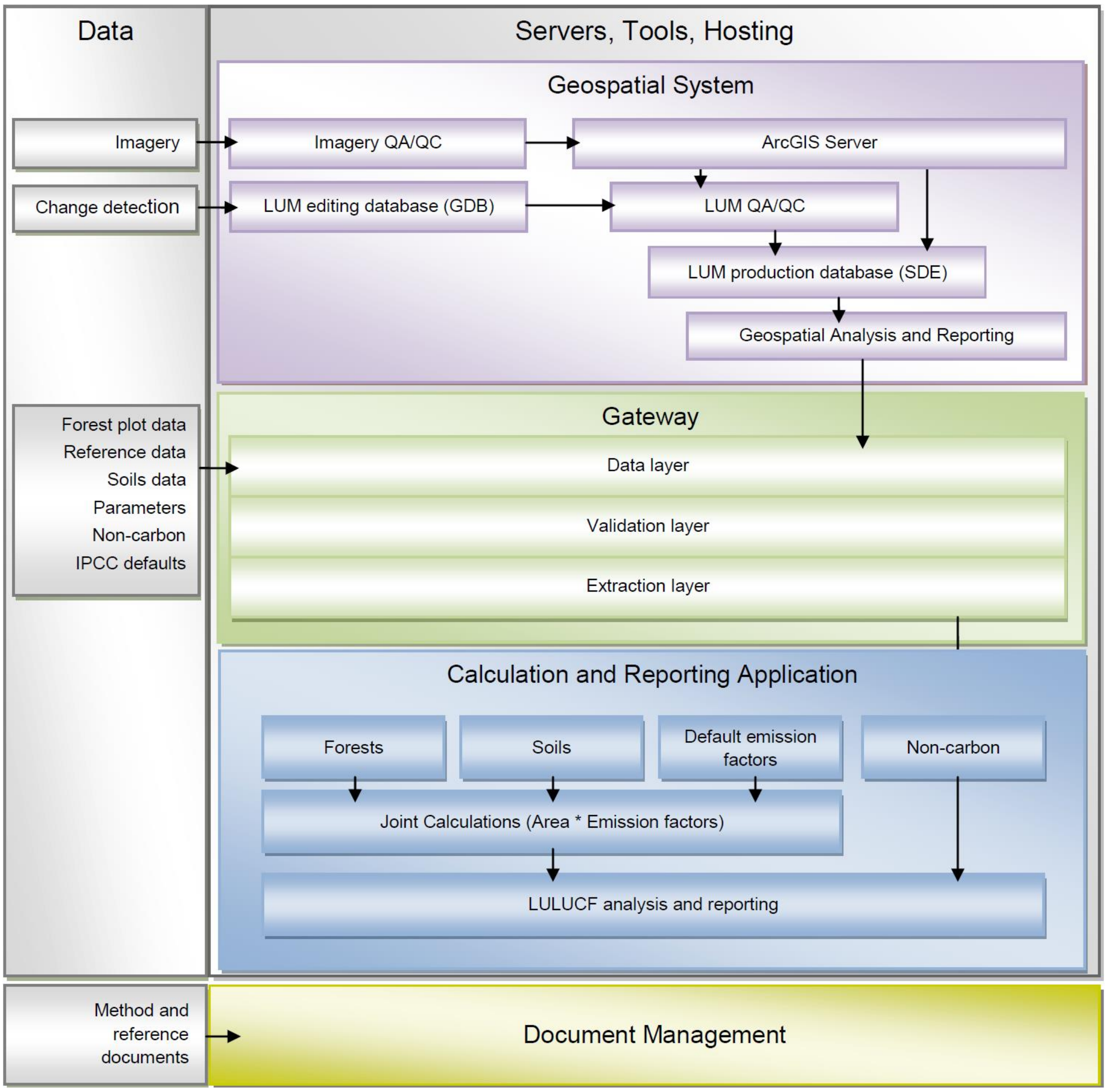
The main objectives of these systems are to:

- provide a transparent system for data storage and carbon calculations
- provide a repository for the versioning and validation of plot measurements and land use data
- calculate carbon stocks, emissions and removals per hectare for land uses and carbon pools based on the plot and spatial data collected
- calculate biomass burning emissions by land use based on area and emission factors stored in the Gateway
- produce the outputs required for the LULUCF sector reporting under the UNFCCC and the Kyoto Protocol
- archive all inputs and outputs used in reporting.

The module 'joint calculations' refers to the process New Zealand uses to estimate national average carbon values by carbon pool for each land use category and subcategory.

The joint calculation process is performed within the CRA. Within the joint calculations interface, the user selects the appropriate area data and emission factors. The results of the calculations are carbon gains, losses and net change for all land use subcategories (whether in a conversion state or land remaining land), by year and by carbon pool.

Figure A3.2.17 New Zealand's LUCAS data management system

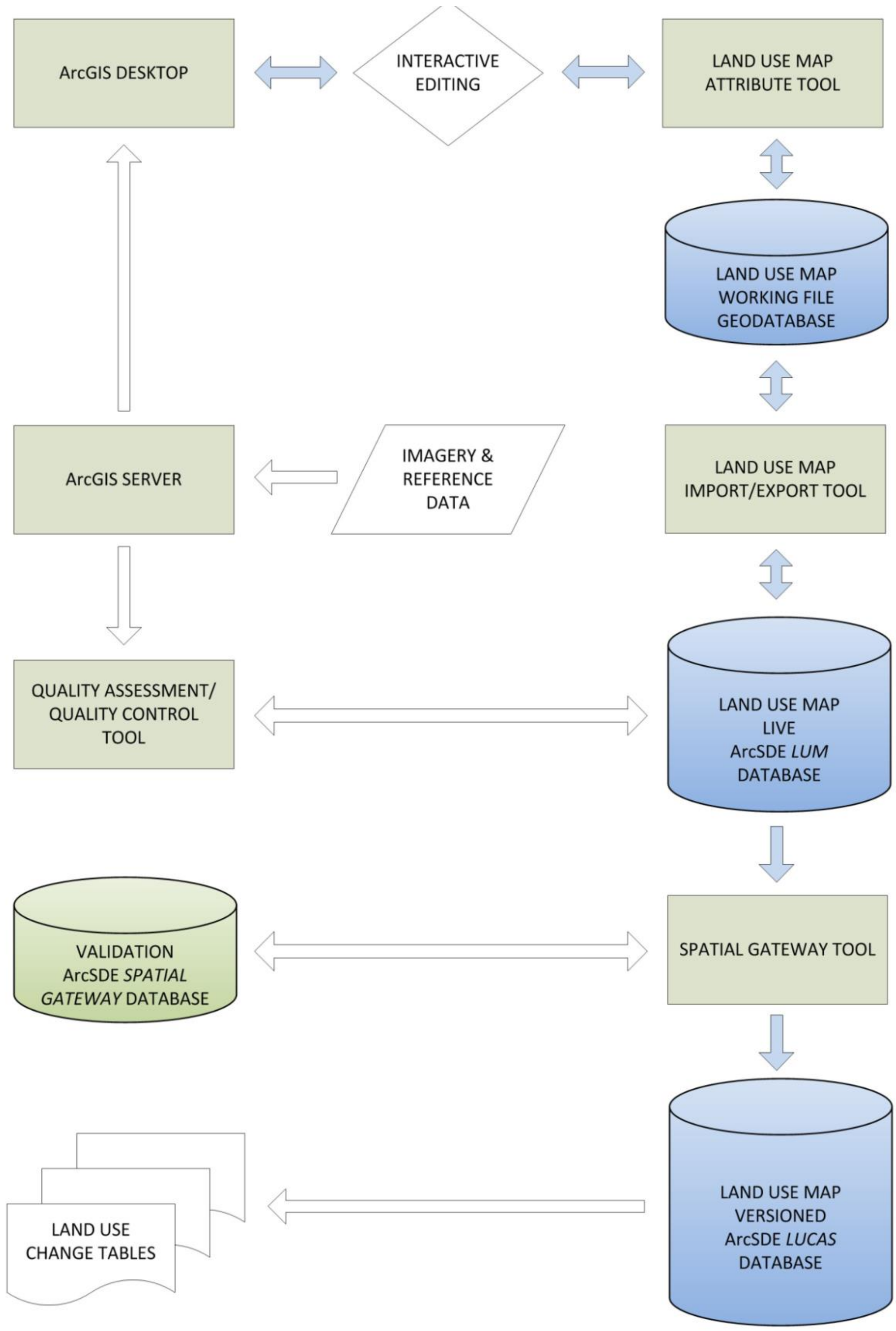


Note: IPCC = Intergovernmental Panel on Climate Change; LULUCF = Land Use, Land-Use Change and Forestry; LUM = land use map; QA/QC = quality assurance/quality control. Joint calculations are described below.

Geospatial System

The Geospatial System consists of hardware and specific applications designed to meet LULUCF reporting requirements. The hardware largely comprises servers for spatial database storage, management, versioning and running web-mapping applications. The core components of the Geospatial System are outlined in figure A3.2.18.

Figure A3.2.18 New Zealand's Geospatial System components



Note: Blue indicates land use mapping data flow. LUCAS = Land Use Carbon Analysis System; LUM = land use map.

Land use mapping functionality

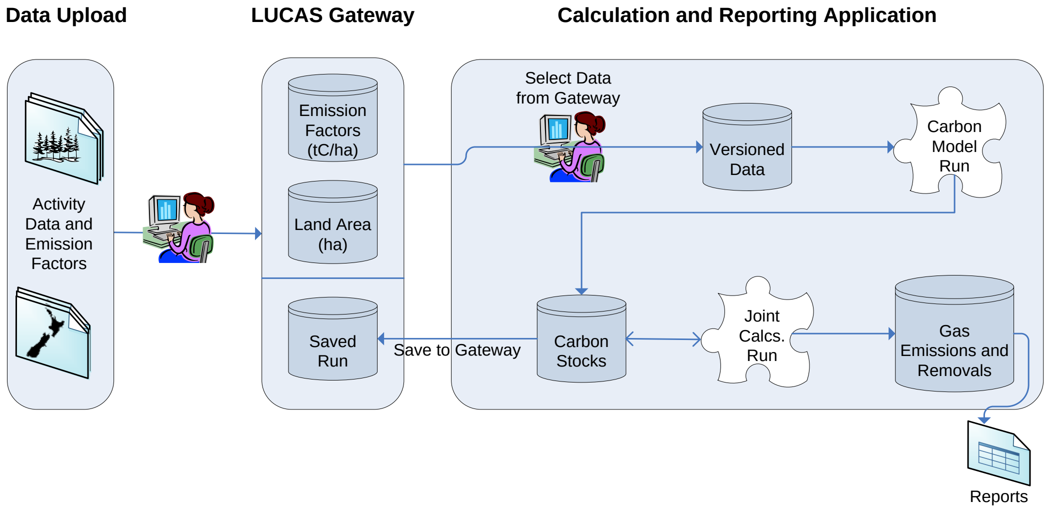
The land use mapping (LUM) functionality of the Geospatial System largely involves the editing and maintenance of time-stamped land use mapping data. The five main components within the LUM functionality are:

- LUM Import/Export Tool – provides functionality for managing the importing and exporting of LUM data in to and out of the database
- LUM Attribute Tool – an extension to the standard ArcGIS Desktop software that facilitates maintenance and updates to the LUM data by external contractors
- LUM Database – a non-versioned GIS database for interim LUM data
- Spatial Gateway Tool – used to validate and version data from the LUM database before loading into the LUCAS GIS database. Validation business rules are stored in the Spatial Gateway database
- LUCAS Database – stores versions of LUM used to derive land-use change reporting.

LUCAS Management Studio

The LUCAS Management Studio (see figure A3.2.19) is the package of applications used to store activity data and calculate and report New Zealand's emissions and removals for LULUCF. The LUCAS Gateway is a data warehouse with the purpose of storing, versioning and validating activity data and emission factors. The CRA sources all data from the Gateway. It then calculates and outputs New Zealand's emissions and removals for LULUCF for land remaining land and land converted to another land use by pool and year.

Figure A3.2.19 LUCAS Management Studio



LUCAS Gateway

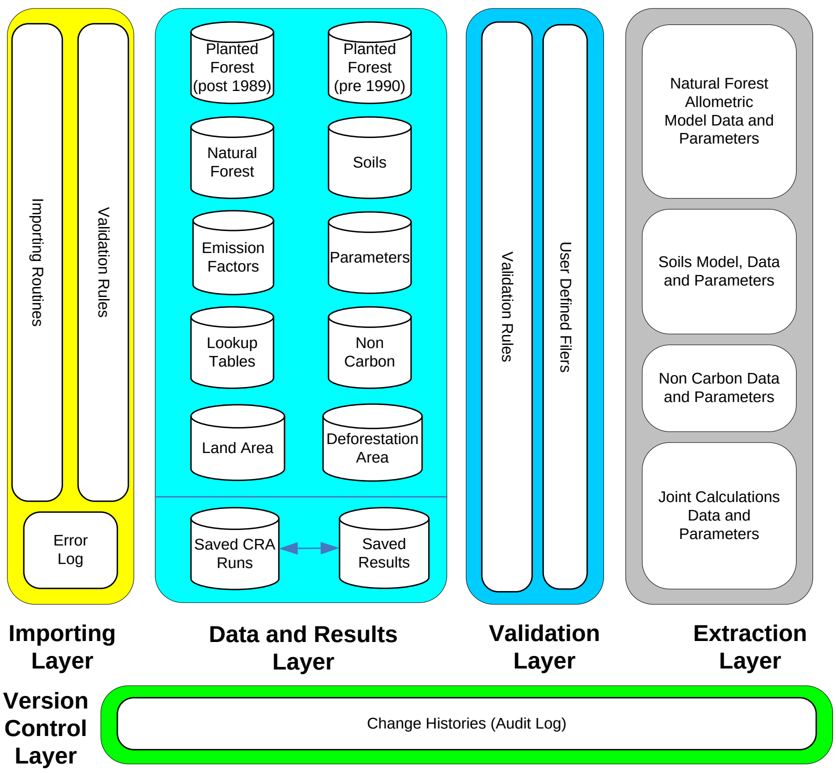
The LUCAS Gateway enables the storage of activity data such as field plot data, land use area, biomass burning and other data needed by the CRA, such as IPCC defaults.

The LUCAS Gateway provides a viewing, querying and editing interface to the source (plot, land use area, carbon and non-carbon) data. It also stores any published or saved results from running the CRA.

All activity data and emission factors are stored within the Gateway database (see figure A3.2.20). It contains the following main components.

- A data and results layer containing all activity data (natural, planted forest, soils, default carbon, non-carbon, land use areas, land-use change and reference tables). The user has the ability to create a 'snapshot' in time (a data set archiving system) of the data held in the Gateway. This enables users of the CRA to select from a range of data snapshots and ensures past results can be replicated over time.
- A validation layer allows users to judge the suitability of data for use in the CRA calculations, subsequent to passing primary validation. Where records are deemed not acceptable for use within published reports, they are tagged as 'invalid' in the LUCAS Gateway database.
- An audit trail provides a history of any changes to the database tables within the Gateway.
- Versioning at a number of levels ensures any changes to data, schema or the database itself are logged and versioned, while providing the user with the ability to track what changes have been applied and roll back to a previous version if required. The results of saved or published reports within the CRA are also stored within the Gateway for repeatability and reference.
- Primary data validation, both during data capture and during import of the data into the Gateway, ensures only data that have passed acceptability criteria are available for a publishable CRA run.
- Hosting and application support provides hosting services, system security, backup and restore, daily maintenance and monitoring for the Gateway and CRA.

Figure A3.2.20 LUCAS Gateway database



Calculation and Reporting Application

The CRA enables users to import carbon and non-carbon data from the Gateway and, by running the various modules, determine emissions and removals by New Zealand's *Forest land*, *Cropland*, *Grassland* and other land use types. This information, combined with land area data, enables New Zealand to meet its reporting requirements under the Convention and the Kyoto Protocol.

The CRA allows for the inclusion of other data sets, models and calculations without the complete redesign of the applications. All models, data and results are versioned, and the CRA allows the user to alter specific key values within a model or calculation (parameters) without the intervention of a programmer or technical support officer. The CRA is deployed as a client-based application that sources the required data from the Gateway.

The CRA comprises four modules: natural forest, soils, non-carbon and joint calculations. Any of these modules can be run independently or as a group. The results are provided as 'views' to the user at the completion of the run.

To activate a module, the user selects the module to run within the CRA, the version of the data set to be used, the model version and other calculation parameters. The natural forest and soil carbon modules use R statistical language as the base program language, while the non-carbon module and joint calculations module are developed in the programming language C Sharp (C#).

Within the joint calculations module, the user has the option of using the carbon results from running the modules or using default carbon estimates (based on published reports) stored within the Gateway. The joint calculations module combines the carbon estimates with the land use area to calculate carbon stock and change following the methodology set out in section 2.3 of volume 4 of the 2006 IPCC Guidelines (IPCC, 2006). The results represent carbon stock and change for every 'from' and 'to' land use combination outlined by the IPCC since 1990.

On completion of running a module, the results can be saved or published back to the Gateway. This provides a versioned and auditable record of the results used for reporting. If the results are saved or published, other information is also saved for tracking and audit control, such as the time created, the user's identification and the module-particular parameters that were used.

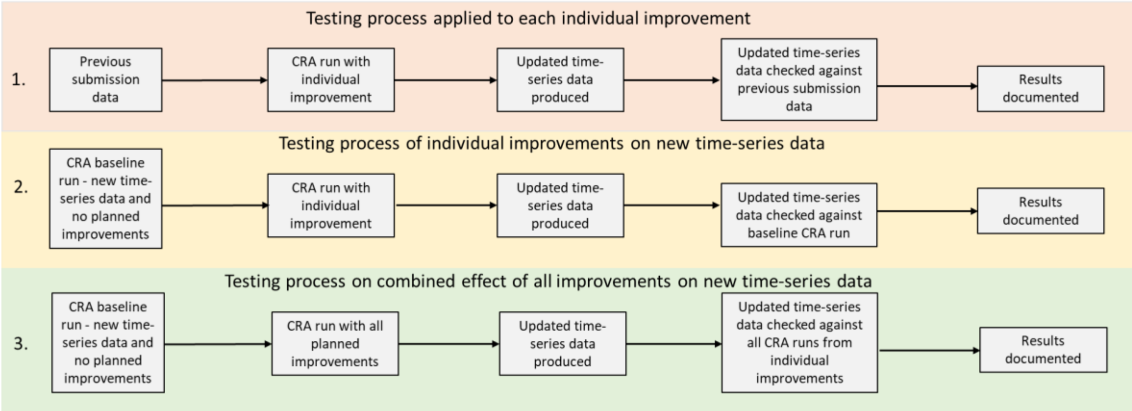
The CRA is maintained and supported by Interpine Innovation, a New Zealand-based company that specialises in forestry inventories and related information technology development. Interpine Innovation also provides support services, such as database and application backups, day-to-day issue resolution and enhancement projects to the Gateway or CRA as required.

Any changes to the data or table structure within the Gateway, or to the people accessing the Gateway or CRA, are tracked via audit logs. For any changes to the data within the Gateway, the person making the change, the date, the reason for change and the version are logged and reports are made available to users for review.

Quality control management for implementing planned improvements

In 2020, further quality control processes were introduced and formalised for introducing improvements to the National Inventory Report. This was done to help manage the large number of improvements to the LULUCF sector that were made for the 2021 submission and to improve the quality control procedures for implementation of future improvements. The quality control process is described in figure A3.2.21.

Figure A3.2.21 Improvements implementation quality control procedure



Document management

All reference material, including scientific reports containing information on methodologies or emission factors used in the production of the LULUCF and Kyoto Protocol estimates, is archived on the Ministry for the Environment's document management store, Te Puna.

The emission factors and area estimates for published runs are also archived within the Gateway and can be accessed via the Gateway or the CRA. Information is not directly accessible by the public but can be supplied upon request.

Annex 3: References

Some references may be downloaded directly from the following webpage: www.mpi.govt.nz/news-and-resources/statistics-and-forecasting/greenhouse-gas-reporting/agriculture-greenhouse-gas-inventory-reports.

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Annex 4: Methodology and data collection for estimating emissions from fossil fuel combustion

New Zealand emission factors are based on gross calorific value. Energy activity data and emission factors in New Zealand are conventionally reported in gross (higher heating value) terms, with some minor exceptions. The convention adopted by New Zealand to convert gross calorific value to net calorific value follows the Organisation for Economic Co-operation and Development and International Energy Agency assumptions:

$$\text{Net calorific value} = 0.95 \times \text{gross calorific value for coal and liquid fuels}$$

$$\text{Net calorific value} = 0.90 \times \text{gross calorific value for gas}$$

$$\text{Net calorific value} = 0.80 \times \text{gross calorific value for wood}$$

Emission factors for gas, coal, biomass and liquid fuels used by New Zealand are shown in tables A4.1–A4.4. Where Intergovernmental Panel on Climate Change (IPCC) default emission factors are used, a net-to-gross factor as above is used to account for New Zealand activity data representing gross energy figures:

$$\text{Gross EF} = \text{Net EF} \times \text{Factor}$$

Table A4.1 Gross carbon dioxide emission factors used for New Zealand's energy sector in 2020

	Emission factor (t CO_2/TJ)	Source
Gas		
Weighted average	53.96	
Liquid fuels		
Crude oil	69.67	1
Regular petrol	66.77	2
Petrol – premium	66.95	2
Diesel (10 parts (sulphur) per million)	69.45	2
Jet kerosene	68.33	2
Av gas	65.89	2
LPG	59.27	3
Heavy fuel oil	73.33	2
Light fuel oil	73.02	2
Bitumen (asphalt)	76.43	2
Biomass		
Biogas	49.17	1
Wood (industrial)	89.47	1
Bioethanol	64.20	4
Biodiesel	67.26	3
Wood (residential)	85.8	3
Coal		
All sectors excl. electricity (sub-bituminous)	91.99	4
All sectors (bituminous)	89.13	4
All sectors (lignite)	93.11	4

1. IPCC Guidelines (2006).
2. Refining NZ.
3. *New Zealand Energy Information Handbook* (Eng et al., 2008).
4. *Review of Default Emission Factors in Draft Stationary Energy and Industrial Processes Regulations: Coal* (CRL Energy, 2009).

Table A4.2 Consumption-weighted average emission factors used for New Zealand's sub-bituminous coal-fired electricity generation for 1990 to 2020

Year	Emission factor (t CO_2/TJ)
1990	91.20
1991	91.24
1992	91.29
1993	91.33
1994	91.38
1995	91.42
1996	91.47
1997	91.51
1998	91.56
1999	91.60
2000	91.64
2001	91.69
2002	91.73
2003	91.78
2004	91.82
2005	91.87
2006	91.91
2007	92.43
2008	92.31
2009	92.39
2010 onwards	92.20

Table A4.3 Methane emission factors used for New Zealand's energy sector for 1990 to 2020

	Emission factor (t CH_4/PJ)	Source
Natural gas		
Electricity industries	0.9	IPCC 2006 (table 2.2)
Commercial	4.50	IPCC 2006 (table 2.4)
Residential	4.50	IPCC 2006 (table 2.5)
Domestic transport (CNG)	82.80	IPCC 2006 (table 3.2.2)
Other stationary (mainly industrial)	0.9	IPCC 2006 (table 2.3)
Liquid fuels		
Stationary sources		
Electricity – residual oil	2.85	IPCC 2006 (table 2.2)
Industrial (including refining) – residual oil	2.85	IPCC 2006 (table 2.3)
Industrial – LPG	0.95	IPCC 2006 (table 2.3)
Commercial – residual oil	9.50	IPCC 2006 (table 2.4)
Commercial – distillate oil	9.50	IPCC 2006 (table 2.4)
Commercial – LPG	4.75	IPCC 2006 (table 2.4)
Residential – distillate oil	9.50	IPCC 2006 (table 2.5)
Residential – LPG	4.75	IPCC 2006 (table 2.5)
Agriculture – stationary	2.85	IPCC 2006 (table 2.5)
Mobile sources		
LPG	58.9	IPCC 2006 (table 3.2.2)
Petrol	28.05	IPCC 2006 (table 3.2.2)
Diesel	3.71	IPCC 2006 (table 3.2.2)
Navigation (fuel oil and diesel)	6.65	IPCC 2006 (table 3.5.3)
Aviation fuel/kerosene	0.48	IPCC 2006 (table 3.6.5)

	Emission factor (t CH_4/PJ)	Source
Coal		
Electricity generation	0.95	IPCC 2006 (table 2.2)
Industry	9.50	IPCC 2006 (table 2.3)
Commercial	9.50	IPCC 2006 (table 2.4)
Residential	285.00	IPCC 2006 (table 2.5)
Biomass		
Wood/wood waste	24	IPCC 2006 (table 2.3)
Wood – fireplaces	240.00	IPCC 2006 (table 2.5) wood – residential
Bioethanol	18.00	IPCC 2006 (table 3.2.2) – ethanol, cars, Brazil
Biodiesel	18.00	IPCC 2006 (table 3.2.2) – ethanol, cars, Brazil
Gas biomass	0.9	IPCC 2006 (table 2.2)

Table A4.4 Nitrous oxide emission factors used for New Zealand's energy sector for 1990 to 2020

	Emission factor (t N_2O/PJ)	Source
Natural gas		
Electricity generation	0.09	IPCC 2006 (table 2.2)
Commercial	0.09	IPCC 2006 (table 2.4)
Residential	0.09	IPCC 2006 (table 2.5)
Domestic transport (CNG)	2.70	IPCC 2006 (table 3.2.2)
Other stationary (mainly industrial)	0.09	IPCC 2006 (table 2.3)
Liquid fuels		
Stationary sources		
Electricity – residual oil	0.57	IPCC 2006 (table 2.2)
Electricity – distillate oil	0.57	IPCC 2006 (table 2.2)
Industrial (including refining) – residual oil	0.57	IPCC 2006 (table 2.2)
Industrial – distillate oil	0.57	IPCC 2006 (table 2.3)
Commercial – residual oil	0.57	IPCC 2006 (table 2.4)
Commercial – distillate oil	0.57	IPCC 2006 (table 2.4)
Residential (all oil)	0.57	IPCC 2006 (table 2.5)
LPG (all uses)	0.095	IPCC 2006 (tables 2.2–2.5)
Agriculture – stationary	0.38	Tier 2, diesel engines – agriculture
Mobile sources		
LPG	0.19	IPCC 2006 (table 3.22)
Petrol	7.6	IPCC 2006 (table 3.2.2)
Diesel	3.71	IPCC 2006 (table 3.2.2)
Fuel oil (ships)	1.90	IPCC 2006 (table 3.5.3)
Aviation fuel/kerosene	1.90	IPCC 2006 (table 3.6.5)
Coal		
Electricity generation	1.43	IPCC 2006 (table 2.2)
Industry	1.43	IPCC 2006 (table 2.3)
Commercial	1.43	IPCC 2006 (table 2.4)
Residential	1.43	IPCC 2006 (table 2.5)
Biomass		
Wood (all uses)	3.20	IPCC 2006 (table 2.5) wood/wood waste
Gas biomass	0.09	IPCC 2006 (table 2.5)

A4.1 Emissions from liquid fuels

A4.1.1 Activity data and uncertainties

The *Delivery of Petroleum Fuels by Industry Survey* is conducted by the Ministry of Business, Innovation and Employment (MBIE). Because it is a census, there is no sampling error. The only possible sources of error are non-sampling errors (such as respondent error and processing error). The 2020 statistical difference for liquid fuels in the balance table of the publication *Energy in New Zealand* was 0.6 per cent (MBIE, 2021). This is used as the activity data uncertainty for liquid fuels in 2020.

A4.1.2 Emission factors and uncertainties

The carbon dioxide (CO_2) emission factors are described in table A4.1. A complete time series of gross calorific values is available online: www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/oil-statistics. Table A4.5 gives a complete time series of carbon content of liquid fuels. This information is supplied by Refining NZ and is used in the calculation of annual emission factors for liquid fuels.

A 2009 consultant report (Hale and Twomey, unpublished) to the Ministry for the Environment estimates the uncertainty of CO_2 emission factors for liquid fuels at ±0.5 per cent. The uncertainty for methane (CH_4) and nitrous oxide (N_2O) emission factors is ±50.0 per cent because almost all emission factors are IPCC defaults.

Table A4.6 provides emission factors for European gasoline and diesel vehicles from the COPERT IV model that are used to estimate non-CO_2 emissions from road transport.

Table A4.5 Carbon content (per cent mass) for liquid fuels for 1990 to 2020

	Premium petrol	Regular petrol	Diesel	Jet kerosene	Heavy fuel oil	Light fuel oil	Bitumen (asphalt)
1990	84.87	84.92	86.28	85.92	86.22	86.67	86.57
1991	85.04	85.04	86.33	85.89	86.26	86.30	86.57
1992	85.03	85.13	86.29	85.84	86.25	86.18	86.57
1993	85.25	85.13	86.32	85.94	86.27	86.20	86.56
1994	85.21	85.19	86.30	85.99	86.25	86.13	86.57
1995	85.30	85.13	86.63	86.05	86.25	86.39	86.57
1996	85.66	85.13	86.73	86.16	86.28	86.45	86.57
1997	85.63	85.04	86.64	86.04	86.35	86.55	86.58
1998	85.72	85.17	86.52	86.14	86.22	86.39	86.63
1999	85.65	85.15	86.69	86.10	86.20	86.53	86.63
2000	85.67	85.16	86.64	86.25	86.22	86.58	86.63
2001	85.65	85.09	86.53	86.18	86.21	86.49	86.64
2002	85.68	85.06	86.57	86.10	86.25	86.68	86.66
2003	85.76	85.19	86.58	86.23	86.23	86.76	86.63
2004	85.66	85.22	86.62	86.20	86.24	86.58	86.58
2005	85.58	85.22	86.62	86.12	86.18	86.52	86.57
2006	85.54	85.25	86.57	86.24	86.34	86.93	86.57
2007	85.54	85.23	86.61	86.24	86.30	86.87	86.57
2008	85.63	85.32	86.70	86.32	86.39	86.87	86.57
2009	85.56	85.38	86.72	86.36	86.37	86.83	86.60

	Premium petrol	Regular petrol	Diesel	Jet kerosene	Heavy fuel oil	Light fuel oil	Bitumen (asphalt)
2010	85.54	85.40	86.77	86.35	86.31	86.90	86.59
2011	85.55	85.37	86.78	86.32	86.37	86.87	86.64
2012	85.51	85.38	86.84	86.34	86.25	86.89	86.63
2013	85.49	85.35	86.73	86.22	86.24	86.68	86.65
2014	85.57	85.42	86.74	86.23	86.33	86.87	86.65
2015	85.54	85.40	86.81	86.33	86.30	86.90	86.62
2016	85.66	85.48	86.56	86.11	86.28	86.58	86.60
2017	85.68	85.46	86.60	86.15	86.30	86.89	86.63
2018	85.69	85.49	86.61	86.31	86.04	86.93	86.04
2019	85.66	85.53	86.65	86.19	85.97	86.96	86.04
2020	85.66	85.53	86.65	86.19	85.97	86.96	86.04

Table A4.6 Emission factors for European gasoline and diesel vehicles – COPERT IV model (European Environment Agency, 2007)

Vehicle type and emission standard	N_2O emission factors (mg/km)				CH_4 emission factors (mg/km)			
	Cold	Urban Hot	Rural	Highway	Cold	Urban Hot	Rural	Highway
Passenger car								
Gasoline								
pre-Euro	10.0	10.0	6.5	6.5	201.0	131.0	86.0	41.0
Euro 1	18.8	26.5	10.7	5.5	45.0	26.0	16.0	14.0
Euro 2	12.6	12.7	4.9	2.7	94.0	17.0	13.0	11.0
Euro 3	8.3	1.50	0.33	0.23	83.0	3.0	2.0	4.0
Euro 4	5.5	1.95	0.34	0.22	57.0	2.87	2.69	5.08
Euro 5	2.15	2.22	0.19	1.20	57.0	2.87	2.69	5.08
Euro 6	2.15	2.22	0.19	1.20	57.0	2.87	2.69	5.08
Diesel								
pre-Euro	0.0	0.0	0.0	0.0	22.0	28.0	12.0	8.0
Euro 1	0.0	2.0	4.0	4.0	18.0	11.0	9.0	3.0
Euro 2	3.0	4.0	6.0	6.0	6.0	7.0	3.0	2.0
Euro 3	15.0	9.0	4.0	4.0	3.0	3.0	0.0	0.0
Euro 4	15.0	9.0	4.0	4.0	1.1	1.1	0.0	0.0
Euro 5	15.0	9.0	4.0	4.0	1.1	1.1	0.0	0.0
Euro 6	9.0	9.0	4.0	4.0	1.1	1.1	0.0	0.0
LPG								
pre-Euro	0.0	0.0	0.0	0.0	80.0	80.0	35.0	25.0
Euro 1	38.0	21.0	13.0	8.0	80.0	80.0	35.0	25.0
Euro 2	23.0	13.0	3.0	2.0	80.0	80.0	35.0	25.0
Euro 3	9.0	5.0	2.0	1.0	80.0	80.0	35.0	25.0
Euro 4	9.0	5.0	2.0	1.0	80.0	80.0	35.0	25.0
Euro 5	1.8	2.1	0.2	1.0	80.0	80.0	35.0	25.0
Euro 6	1.8	2.1	0.2	1.0	80.0	80.0	35.0	25.0
Light duty vehicles								
Gasoline								
pre-Euro	10.0	10.0	6.5	6.5	201.0	131.0	86.0	41.0

Vehicle type and emission standard	N_2O emission factors (mg/km)				CH_4 emission factors (mg/km)			
	Urban		Rural	Highway	Urban		Rural	Highway
	Cold	Hot			Cold	Hot		
Euro 1	47.3	46.3	27.5	13.8	45.0	26.0	16.0	14.0
Euro 2	83.8	27.7	15.8	12.3	94.0	17.0	13.0	11.0
Euro 3	17.1	8.5	1.5	1.5	83.0	3.0	2.0	4.0
Euro 4	14.1	1.17	0.36	0.36	57.0	2.0	2.0	0.0
Euro 5	2.10	2.22	0.19	1.20	57.0	2.0	2.0	0.0
Euro 6	2.10	2.22	0.19	1.20	57.0	2.0	2.0	0.0
Diesel								
pre-Euro	0.0	0.0	0.0	0.0	22.0	28.0	12.0	8.0
Euro 1	0.0	2.0	4.0	4.0	18.0	11.0	9.0	3.0
Euro 2	3.0	4.0	6.0	6.0	6.0	7.0	3.0	2.0
Euro 3	15.0	9.0	4.0	4.0	3.0	3.0	0.0	0.0
Euro 4	15.0	9.0	4.0	4.0	1.1	1.1	0.0	0.0
Euro 5	15.0	9.0	4.0	4.0	1.1	1.1	0.0	0.0
Euro 6	9.0	9.0	4.0	4.0	1.1	1.1	0.0	0.0
Heavy duty truck and bus								
Gasoline all technologies	6.0	6.0	6.0	6.0	140.0	140.0	110.0	70.0
Diesel								
		GVW≤12t				GVW≤12t		
pre-Euro	30.0	30.0	30.0	30.0	85.0	85.0	23.0	20.0
Euro I	6.0	6.0	5.0	3.0	85.0	85.0	23.0	20.0
Euro II	5.0	5.0	5.0	3.0	54.4	54.4	20.0	18.6
Euro III	3.0	3.0	3.0	2.0	47.6	47.6	21.4	18.2
Euro IV	6.0	6.0	7.2	5.8	2.6	2.6	1.6	1.2
Euro V	15.0	15.0	19.8	17.2	2.6	2.6	1.6	1.2
Euro VI	18.5	18.5	19.0	15.0	2.6	2.6	1.6	1.2
		12t<GVW≤16t				12t<GVW≤16t		
pre-Euro	30.0	30.0	30.0	30.0	85.0	85.0	23.0	20.0
Euro I	11.0	11.0	9.0	7.0	85.0	85.0	23.0	20.0
Euro II	11.0	11.0	9.0	6.0	54.4	54.4	20.0	18.6
Euro III	5.0	5.0	5.0	4.0	47.6	47.6	21.4	18.2
Euro IV	11.2	11.2	13.8	11.4	2.6	2.6	1.6	1.2
Euro V	29.8	29.8	40.2	33.6	2.6	2.6	1.6	1.2
Euro VI	37.0	37.0	39.0	29.0	2.6	2.6	1.6	1.2
		16t<GVW≤28t				16t<GVW≤28t		
pre-Euro	30.0	30.0	30.0	30.0	175.0	175.0	80.0	70.0
Euro I	11.0	11.0	9.0	7.0	175.0	175.0	80.0	70.0
Euro II	11.0	11.0	9.0	6.0	112.0	112.0	69.6	65.1
Euro III	5.0	5.0	5.0	4.0	98.0	98.0	74.4	63.7
Euro IV	11.2	11.2	13.8	11.4	5.3	5.3	5.6	4.2
Euro V	29.8	29.8	40.2	33.6	5.3	5.3	5.6	4.2
Euro VI	37.0	37.0	39.0	29.0	5.3	5.3	5.6	4.2
		28t<GVW≤34t				28t<GVW≤34t		

Vehicle type and emission standard	N_2O emission factors (mg/km)				CH_4 emission factors (mg/km)			
	Urban		Rural	Highway	Urban		Rural	Highway
	Cold	Hot			Cold	Hot		
pre-Euro	30.0	30.0	30.0	30.0	175.0	175.0	80.0	70.0
Euro I	17.0	17.0	14.0	10.0	175.0	175.0	80.0	70.0
Euro II	17.0	17.0	14.0	10.0	112.0	112.0	69.6	65.1
Euro III	8.0	8.0	8.0	6.0	98.0	98.0	74.4	63.7
Euro IV	17.4	17.4	21.4	17.4	5.3	5.3	5.6	4.2
Euro V	45.6	45.6	61.6	51.6	5.3	5.3	5.6	4.2
Euro VI	56.5	56.5	59.5	44.5	5.3	5.3	5.6	4.2
		GVW>34t				GVW>34t		
pre-Euro	30.0	30.0	30.0	30.0	175.0	175.0	80.0	70.0
Euro I	18.0	18.0	15.0	11.0	175.0	175.0	80.0	70.0
Euro II	18.0	18.0	15.0	10.0	112.0	112.0	69.6	65.1
Euro III	9.0	9.0	9.0	7.0	98.0	98.0	74.4	63.7
Euro IV	19.0	19.0	23.4	19.2	5.3	5.3	5.6	4.2
Euro V	49.0	49.0	66.6	55.8	5.3	5.3	5.6	4.2
Euro VI	61.0	61.0	64.0	48.0	5.3	5.3	5.6	4.2
Urban bus or coach		All types				All types		
pre-Euro	30.0	30.0	30.0	30.0	175.0	175.0	80.0	70.0
Euro I	12.0	12.0	9.0	7.0	175.0	175.0	80.0	70.0
Euro II	12.0	12.0	9.0	6.0	113.8	113.8	52.0	45.5
Euro III	6.0	6.0	5.0	4.0	103.3	103.3	47.2	41.3
Euro IV	12.8	12.8	13.8	11.4	5.3	5.3	2.4	2.1
Euro V	33.2	33.2	40.2	33.6	5.3	5.3	2.4	2.1
Euro VI	41.5	41.5	39.0	29.0	5.3	5.3	2.4	2.1
CNG								
pre-Euro					6,800	6,800	6,800	6,800
Euro I					6,800	6,800	6,800	6,800
Euro II					4,500	4,500	4,500	4,500
Euro III					1,280	1,280	1,280	1,280
Euro IV and later					980	980	980	980
Power two wheeler								
Gasoline								
<50 cm^3	1.0	1.0	1.0	1.0	219	219	219	219
>50 cm^3 2-stroke	2.0	2.0	2.0	2.0	150	150	150	150
>50 cm^3 4-stroke	2.0	2.0	2.0	2.0	200	200	200	200

A4.2 Emissions from solid fuels

A4.2.1 Activity data and uncertainties

The *New Zealand Quarterly Statistical Return of Coal Production and Sales* conducted by MBIE has near coverage of the sector, meaning that sampling error is small. The only other possible sources of error are non-sample errors (such as respondent error and processing error). The 2020 statistical difference for solid fuels in the balance table of the publication *Energy in New Zealand* was 2.7 per cent (MBIE, 2021). This is used as the activity data uncertainty for solid fuels in 2020.

A4.2.2 Emission factors and uncertainties

The estimated uncertainty in CO_2 emission factors for solid fuels is ±2.2 per cent. This is based on the difference between the range of updated emission factors for the three different ranks of coal used in New Zealand. The uncertainty for CH_4 and N_2O emission factors is ±50.0 per cent because almost all emission factors are IPCC defaults.

A4.3 Emissions from gaseous fuels

A4.3.1 Activity data

Through the various surveys and information it collects, MBIE has full coverage of the natural gas sector. This means that there is no sampling error in natural gas statistics and the only possible sources of error include those such as respondent error and processing error. The 2020 statistical difference for gaseous fuels in the balance table of the publication *Energy in New Zealand* was 4.4 per cent (MBIE, 2021). This is used as the activity data uncertainty for gaseous fuels in 2019.

A4.3.2 Emission factors

The estimated uncertainty in CO_2 emission factors for gaseous fuels is ±2.4 per cent. This is based on the difference between the range of emission factors for three large gas fields in New Zealand. Together, these gas fields contributed over half of New Zealand's total gas supply in 2020. The uncertainty for CH_4 and N_2O emission factors is ±50.0 per cent because almost all emission factors are IPCC defaults.

A4.4 Energy balance

Detailed and up-to-date energy balance tables for New Zealand are available online: www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/energy-balances.

Further information can be found within the publication *Energy in New Zealand* (MBIE, 2021), which is also available online: www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-publications-and-technical-papers/energy-in-new-zealand.

Table A4.7 gives a time series of energy use versus non-energy use of natural gas.

Table A4.7 Split of energy use and non-energy use of natural gas in petajoules

	Energy use	Non-energy use
1990	129.5	14.2
1991	143.9	22.1
1992	152.6	18.8
1993	148.0	21.1
1994	137.7	25.8
1995	127.4	36.2
1996	147.7	47.5
1997	170.4	48.9
1998	146.2	46.6

	Energy use	Non-energy use
1999	168.5	54.2
2000	173.9	61.8
2001	190.6	55.4
2002	177.1	57.8
2003	151.9	26.1
2004	129.8	32.1
2005	136.4	13.0
2006	137.2	15.0
2007	148.6	15.4
2008	135.5	18.4
2009	132.5	25.5
2010	147.1	25.6
2011	133.5	24.5
2012	145.6	32.0
2013	148.2	40.3
2014	149.5	60.7
2015	141.4	51.4
2016	133.3	59.1
2017	145.9	53.8
2018	134.8	45.3
2019	140.8	51.3
2020	136.3	46.6

A4.5 Carbon dioxide reference approach for the Energy sector

A4.5.1 Estimation of carbon dioxide using the IPCC reference approach

The reference approach uses a country's energy supply data to calculate the CO_2 emissions from the combustion of fossil fuels using the apparent consumption equation. The apparent consumption in the reference approach is derived from production, import and export data. This information is included as a check for combustion-related emissions calculated from the sectoral approach.

The apparent consumption for primary fuels in the reference approach is obtained from 'calculated' energy-use figures (see annex 2 and section A4.4). These are derived as a residual figure from an energy balance equation comprising production, imports, exports, stock change and international transport on the supply side, according to the IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006).

The majority of the CO_2 emission factors for the reference approach are specific to New Zealand. Most emission factors for liquid fuels are based on annual carbon content and the gross calorific value data provided by New Zealand's only oil refinery, The New Zealand Refining Company Ltd. Where these data are not available, an IPCC default is used. The natural gas emission factor is based on a production-derived, weighted average of emission factors from all gas production fields.

Solid fuels in iron and steel manufacture

As mentioned in chapter 3, section 3.2.3, some of the coal production activity data in the reference approach are used in steel production. The Industrial Processes and Product Use sector accounts for the CO_2 emissions from this coal in the sectoral approach, as recommended by the IPCC Guidelines (IPCC, 2006); therefore they are not included in the common reporting format table 1.AA *Fuel combustion* – sectoral approach.

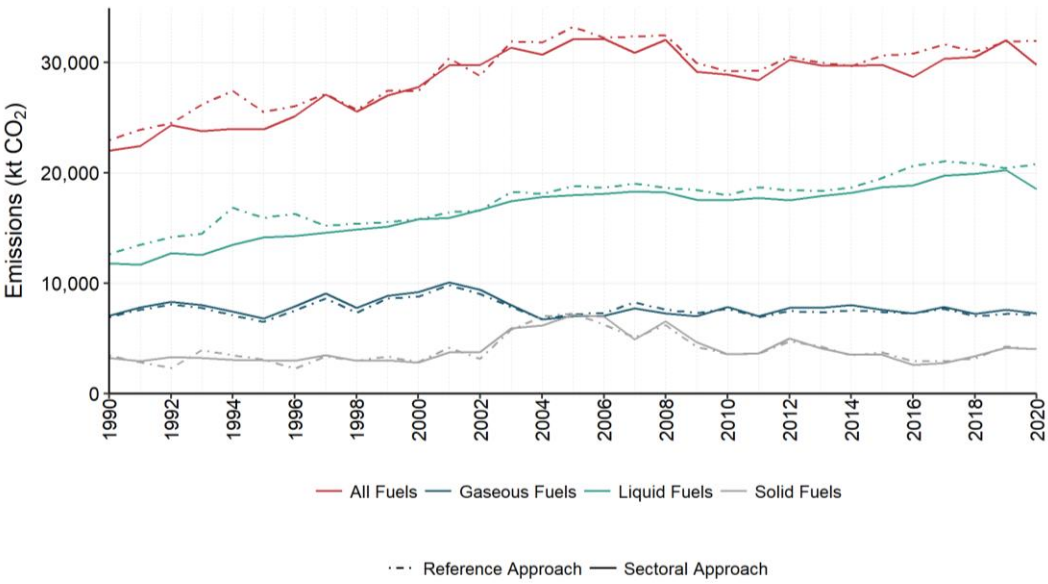
For simplicity, all feedstock carbon is excluded from the reference approach according to the IPCC Guidelines (IPCC, 2006). Without taking into account the use of by-product gases, this can create some discrepancies between the reference and sectoral approaches.

A4.5.2 Comparison of the IPCC reference approach with the New Zealand sectoral methodology

For 2020, CO_2 emissions estimated with the sectoral approach were 6.7 per cent lower than those estimated with the reference approach. Figure A4.1 shows the results for the two approaches for the period 1990 to 2020.

In some years, differences exist between the reference and sectoral approaches. Much of this is due to the statistical differences found in the energy balance tables (MBIE, 2021) that are used as the basis for the reference and sectoral approach. Since 2000, the standard of national energy data has improved significantly, due to increased resources and focus. In 2008, Stats NZ delegated responsibility for the collection and analysis of national energy data to MBIE. Before 2008, various energy statistics were collected by Stats NZ or MBIE. The change resulted in a more consistent and transparent approach to energy data collection because one agency collected data across the supply chain.

Figure A4.1 Reference and sectoral approach carbon dioxide by fuel type (kt CO_2)



Sources of differences

- For gaseous fuels, the field-specific emission factors are used for natural gas supplied for industrial processes, while the reference approach uses an average emission factor.
- For liquid fuels, the energy balance is mass balanced but not carbon balanced. The fuel category 'other oil' is an aggregation of several fuel types, and so it is difficult to quantify a reliable carbon emission factor for the reference approach.
- In the sectoral approach, sector- or even plant-specific calorific values are used to calculate energy consumption, whereas in the reference approach, average (country-specific) calorific values are applied.

Annex 4: References

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Annex 5: Supplementary information for the KP-LULUCF sector

A5.1 Technical corrections to the FMRL

A5.1.1 Introduction

For the second commitment period, reporting on *Forest management* under the Kyoto Protocol is mandatory. Accounting for *Forest management* during the second commitment period is relative to a forest management reference level (FMRL) (Decision 2/CMP.7, UNFCCC, 2012).

New Zealand's FMRL was initially set at 11.15 million tonnes carbon dioxide equivalent (Mt CO_2-e) on average per year for the period 2013 to 2020 (New Zealand Government, 2011). This value was constructed using a business-as-usual projection of pre-1990 planted forest growth and harvest for the period 2013 to 2020. It was based on yield tables and statistics on the area in each age class of pre-1990 planted forest from the National Exotic Forest Description (NEFD) as at 2009 (Ministry for Primary Industries, 2009).

The 2011 FMRL included the following assumptions:

- pre-1990 natural forests were in steady state
- no pre-1990 planted forest deforestation would occur between 2013 and 2020 (pre-1990 natural forests were excluded from the analyses; post-1989 forest deforestation is reported under Article 3.3 – *Deforestation*)
- between 2013 and 2020, 2,000 hectares per year would be converted to non-forest land, and the equivalent forest would be planted elsewhere (i.e., 2,000 hectares per year would be reported as carbon equivalent forest (CEF) and be accounted for under *Forest management*)
- while harvest of post-1989 planted forest will increase over the period, pre-1990 planted forests will still make up a substantial proportion of total forest harvest
- all carbon is instantly emitted at the time of harvest (emissions and removals by the *Harvested wood products* pool were not considered)
- no allowance was made for the impacts of potential natural disturbances beyond background levels captured in the carbon stock yield tables.

The FMRL also reflects the following New Zealand legislation (including amendments) and current policies:

- the Forest Act 1949, which regulates the removal of timber from natural indigenous forests
- the South Island Landless Natives Act 1906, which transferred 17,000 hectares of natural indigenous forest to South Island Māori. The harvesting of this forest is also subject to the Resource Management Act 1991
- the Climate Change Response Act 2002, which makes owners of pre-1990 planted forest who deforest liable for the emissions associated with that activity

- the New Zealand's biofuels policy of the time (under which it was thought most feedstock for biofuel was likely to be derived from non-forest sources).

It was assumed that this legislation and these policies would prevent any significant deforestation of pre-1990 forests, and that the New Zealand Emissions Trading Scheme would encourage harvest in pre-1990 planted forests over post-1989 forest.

The 2011 FMRL was determined by modelling the pre-1990 planted forest estate using a Forestry-Oriented Linear Programming Interpreter (FOLPI). As mentioned above, the model developed in FOLPI was based on an age-class distribution of pre-1990 planted forest as at 2009 from the NEFD, and simulated expected harvesting and replanting of this forest. Some additional modelling of decay of residues from harvest events was also carried out in MS Excel.

Since the 2011 FMRL was submitted, supplementary guidance has been prepared that describes the circumstances that would trigger a technical correction to the FMRL (IPCC, 2014). Changes to policies that affect harvest rate (as listed above) cannot be corrected for, but corrections can be made to reflect changes to the method for reporting against the FMRL and to address recommendations made by United Nations Framework Convention on Climate Change (UNFCCC) expert review teams (ERTs).

A technical assessment of New Zealand's reference level submission was carried out by an ERT in 2011 (UNFCCC, 2011). The ERT noted a number of items for New Zealand to address by either providing additional data or applying technical corrections. These items included (UNFCCC, 2011, pp 6–10):

- maintaining consistency in the fraction of harvested biomass instantly oxidised when estimating emissions from harvest in the FMRL and in reporting against it (paragraph 21)
- ensuring consistency between the National Inventory Report (NIR) and the FMRL and, therefore, updating the current FMRL when new data or information become available (paragraph 22)
- making efforts to disaggregate gains and losses by biomass pool (paragraph 35)
- providing further information on how forest owners will be able to move from historical and current harvesting practice to the longer rotation length projected in the FOLPI model (paragraph 36)
- explaining in more detail how the difference in both harvested areas and harvesting age as calculated by FOLPI could be achieved (paragraph 36)
- comparing the results provided in its submission with a rerun of the FOLPI model in which the harvesting of over-mature forests (over 32 years of age) is constrained, and modify the reference level accordingly if necessary (paragraph 36)
- if estimates for natural forests are included in future NIR submissions, making a technical adjustment of the FMRL (paragraph 37)
- agreeing that in the future a technical correction should be made to incorporate the *Harvested wood products* pool (paragraph 38).

A5.1.2 Technical corrections required

For the 2016 submission, the following technical corrections were made to meet IPCC guidance and address recommendations by the UNFCCC ERT. These aimed to:

1. ensure consistency between the method used for greenhouse gas reporting of *Forest management* and that used to calculate the FMRL (IPCC, 2014, sections 2.7.5.2 and 2.7.6). This involved making changes to:
    a. align forest area estimates
    b. align CEF emissions calculation methods
    c. include overplanting estimates (pre-1990 natural forest conversions to pre-1990 planted forest)
    d. include non-carbon emissions
2. include an estimate for pre-1990 natural forest emissions following completion of the re-measurement of the pre-1990 natural forest inventory and subsequent analysis
3. address new elements of Decision 2/CMP.7 including:
    a. accounting for *Harvested wood products* (processed domestically)
    b. the application of the natural disturbances provision.

For the 2019 submission, an additional technical correction was applied to the FMRL to capture improvements to the *Harvested wood products* estimates on exported, unprocessed logs.

For the 2021 submission, a technical correction was made to address a number of methodological inconsistencies between emissions estimated for *Forest management* and those used to calculate the FMRL, including:

1. aligning pre-1990 natural forest methods
2. aligning the pre-1990 planted forest yield tables
3. correcting a model assumption to align the harvesting projections with the *Harvested wood products* estimates
4. correcting the background disturbance level and aligning this calculation with the FMRL.

For the 2022 submission, the final submission under the 2013 to 2020 commitment period, a further technical correction has been made. The FMRL has been updated to respond to preliminary recommendations the ERT made during the review of the 2021 submission, as well as to align the methods used to calculate emissions from *Forest management* with those used to calculate the FMRL. In summary, the updates that have been applied to the technically corrected FMRL involve:

1. applying a number of changes to pre-1990 planted forest in the calculation of emissions for *Forest management*. Updates to the FMRL have been applied to ensure consistency between the methods used to calculate *Forest management* and the FMRL. They include:
    a. updating the harvest area by age and forest age profile calculations
    b. using input data to produce the FMRL based on the method change applied for calculating the forest age profile and harvest age profile
2. updating the planted forest model to ensure that the forest age profile at 2009 is consistent with the NIR
3. removing the projected rate of deforestation and carbon equivalent forests for pre-1990 planted forests and natural forests from 2010 to 2020. The area of both forests is now assumed to remain constant from 2009 onwards
4. removing the previous technical correction applied to include net emissions from overplanting between 2010 and 2013, where pre-1990 natural forest is removed and replaced with planted forest.

5. updating the yield tables used for measuring *Forest management* emissions for pre-1990 planted forest to make it consistent with the approach for reporting *Forest management* emissions for pre-1990 planted forest
6. updating the emission factors and area estimates for pre-1990 natural forest to make them consistent with the approach for reporting *Forest management* emissions for pre-1990 natural forest
7. updating the *Harvested wood products* model input data to make them consistent with the revised above-ground biomass (AGB) harvest removals as part of this technical correction (to align with items 5 and 6 below), and so that the model approach and assumptions are consistent with the approach used to estimate emissions from *Forest management.*

Further detail on each of these updates to the FMRL is provided in the section below.

Technical corrections: Addressing methodological inconsistencies between the 2011 FMRL and *Forest management* reporting

Replicate the FMRL using the inventory reporting system

The first step taken to calculate technical corrections to the FMRL was to replicate the FMRL as submitted in 2011, applying the same policy assumptions, but using the reporting system and historical data that are used to report on *Forest management* in the inventory.

This technical correction addresses two of the findings of the technical assessment (listed above) by:

1. maintaining consistency in the fraction of harvested biomass instantly oxidised
2. ensuring consistency between the emissions reported in the inventory for *Forest management* and the FMRL.

The original 2011 FMRL submissions assumed that 85 per cent of stem carbon is removed on harvest. For the estimate for pre-1990 planted forest, the NIR assumed that 70 per cent of AGB is removed on harvest. These two ratios are roughly equivalent, when converting stem carbon to AGB.

As the technically corrected forest management reference level ($FMRL_{corr}$) was re-created using the same reporting system as used for *Forest management* in the inventory, a technical correction was applied so that 70 per cent of AGB is assumed to be removed on harvest.

To ensure consistency in historical emissions from planted forest emissions reported in chapter 11 for *Forest management* and the $FMRL_{corr}$, the same underlying activity data and emission factor data were used for the $FMRL_{corr}$ up to 2009. This results in the following updates to be made to the FMRL:

- adjusting the forest area estimate to be consistent at 2009
- adjusting the planted forest age profile to be consistent at 2009
- adjusting the harvest and deforestation area by age estimates to be consistent from 1990 to 2009.

Further details of these technical corrections to historical activity data are provided below.

Aligning forest area estimates

The total area for pre-1990 planted forest as at 2009 for the 2011 FMRL was not consistent with the area estimate for the *Forest management*.

The 2011 FMRL submission was based on data derived from the 2010 NEFD (Ministry for Primary Industries, 2010). The NEFD is an annual survey of forest owners that represents the 'net stocked area' of the planted production forest estate established with the primary intention of producing wood or fibre. The Land Use and Carbon Analysis System (LUCAS), which is used for reporting emissions for *Forest management* in the inventory, uses complete wall-to-wall mapping to estimate forest area. This means LUCAS maps to a 'gross stocked area' where harvested areas, skid sites, forest roads and unstocked gullies are included in the mapped forest area. This gross stocked area is also the basis for the national sampling system used for deriving emission factors for the *Forest land* use classes.

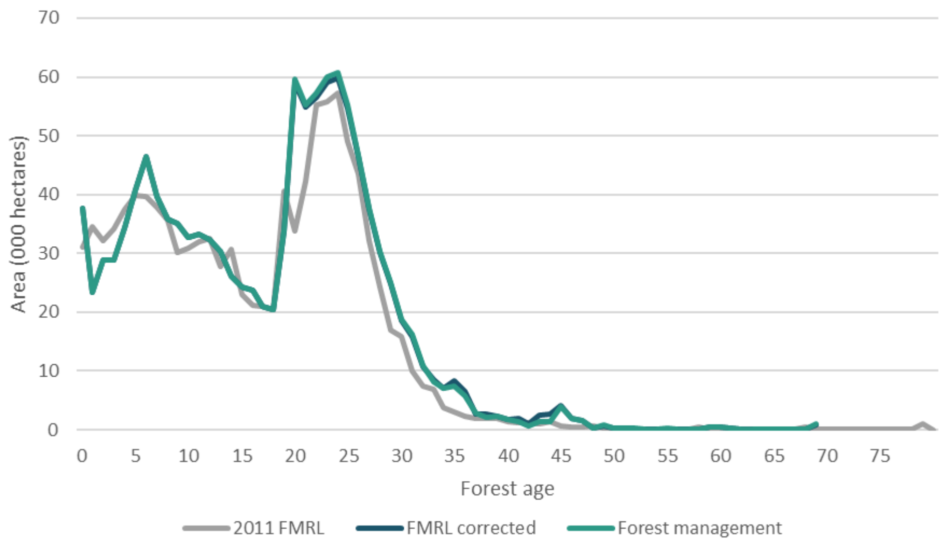
For modelling emissions for reporting under the UNFCCC, LUCAS has isolated the net stocked area from the mapped gross stocked area so the modelled area is compatible between the two data sources (LUCAS and NEFD). The LUCAS gross stocked area of pre-1990 planted forest area is 1.47 million hectares as at 2009. The LUCAS net stocked area, as at 2009, is estimated to be 1.25 million hectares (a 12.4 per cent difference).

In comparison, 1.14 million hectares was estimated from the NEFD as at 2009 for the 2011 FMRL. Because the 2011 FMRL did not take into account differences in the data sources due to the two purposes for which the data are collected, a technical correction is required to correct the original NEFD-based FMRL to the LUCAS mapped area estimates used for reporting for *Forest management*.

Aligning the planted forest age profile at 2009

A technical correction was applied to the pre-1990 planted forest age profile at 2009, to be consistent with the forest age profile reported for pre-1990 planted forest (*Forest management*) in this submission (see figure A5.1.1). This was achieved by using the same forest area, harvesting and deforestation data up to 2009 as used for reporting *Forest management*. This required an update to the estimated harvest and deforestation area at 2009, which was based on a projection in the original 2011 FMRL.

Figure A5.1.1 Pre-1990 planted forest age profile as at 2009, as reported for the original 2011 FMRL, the FMRL*corr* and *Forest management*



Harvest data

The annual harvest area estimate from 2010 to 2020 remains the same as the original 2011 FMRL. This is because this estimate of harvest area is considered to be part of the underlying policy assumptions of the original 2011 FMRL, and so would not meet the criteria for a technical correction.

A technical correction was applied to the average harvest age from 2010 to 2020. The 2011 FMRL predicted an average harvest age of between 31 and 33 years from 2010 to 2020. A technical correction was applied to adjust this down to range between 28 and 30 years over this period (see table A5.1.1). This is to address issue 9 that the ERT raised in the technical assessment of the FMRL submitted in 2011 (UNFCCC, 2011): that harvest ages in the projection were older than those observed historically and there were no policies in place that would influence rotation length or change the average harvest ages of planted forests. The updated average harvest ages are now more consistent with the historical time series, while increasing slightly through time to account for the increasing area of older stands that are projected to be available for harvest.

When adjusting the average harvest age down, the same harvest age profile (proportion of harvest area by age) was also included in this FMRL technical correction. This ensures methodological consistency in the approach to estimate harvest area by age with *Forest management*.

Table A5.1.1 Pre-1990 planted forest data used to estimate emissions for the technically corrected FMRL

Year	Pre-1990 planted forest deforestation (kha)	Pre-1990 planted forest harvested (kha)	Pre-1990 planted forest harvest average age (years)
1990	–	19.288	28.9
1991	–	19.801	29.0
1992	–	22.557	29.0
1993	–	23.194	28.9
1994	–	24.919	28.8
1995	–	29.194	28.7
1996	–	31.169	28.3
1997	–	32.093	28.2
1998	–	31.494	27.9
1999	–	33.994	27.6
2000	2.746	34.726	27.2
2001	2.668	38.541	27.3
2002	2.075	45.290	27.4
2003	3.557	39.643	27.6
2004	7.105	33.260	27.7
2005	12.852	27.760	28.1
2006	16.175	27.765	28.4
2007	21.463	23.168	28.5
2008	3.773	37.425	28.6
2009	5.561	37.160	28.8
2010	0	33.086	28.4
2011	0	37.479	28.4
2012	0	41.354	28.6
2013	0	46.112	28.7
2014	0	50.021	28.9
2015	0	49.697	29.2

Year	Pre-1990 planted forest deforestation (kha)	Pre-1990 planted forest harvested (kha)	Pre-1990 planted forest harvest average age (years)
2016	0	49.724	29.4
2017	0	50.018	29.8
2018	0	49.967	30.1
2019	0	45.817	30.2
2020	0	43.817	30.5

Carbon equivalent forests

Projections for changes in carbon stocks dues to CEF were included in the 2011 FMRL. Technical corrections to the FMRL for CEF had previously been applied to ensure consistency with the provisions of Decision 2/CMP.7 (UNFCCC, 2012) and the guidance for reporting (IPCC, 2014). However, following the review of the 2020 submission (see KL.16, 2019) and the 2021 submission, the step of removing CEF from the FMRL entirely was discussed with the ERT, and included in the ERT's preliminary findings of the 2021 submission. This is because the establishment of a CEF is a deviation from the 'business-as-usual' management of forest land. As such, its impact should not be included in the FMRL and the decision to apply the CEF provision does not trigger a technical correction (IPCC, 2014, p.2.101).

Overplanting

Overplanting is where pre-1990 natural forest is converted to planted forest. In previous submissions, a technical correction has been applied to account for the emissions that were projected to occur as a result of this management practice. However, the ERT review of the 2019 submission noted in KL.14, 2019 (UNFCCC, 2019) that this technical correction was not in accordance with the Kyoto Protocol Supplement (IPCC, 2014, section 2.7.5.1) nor with guidance provided in appendix II to Decision 2/CMP.6 because the conversion of natural forest to a forest plantation is considered a change in management practice.

This finding was again noted by the ERT during the review of the 2021 submission. Therefore, the technical correction for overplanting has been removed from this submission. Note that this change for the 2022 submission does not deviate from the original FMRL and corrections for overplanting are no longer included in the $FMRL_{corr}$. This explanatory text has been included in the annex to explain why a previously applied technical correction has been removed and to demonstrate that the ERT recommendation KL.14, 2019 (UNFCCC, 2019) has been addressed.

Non-carbon emissions

Non-carbon emissions were not included in the 2011 FMRL submission; therefore, a technical correction is required to include these emissions. Non-carbon emissions are estimated based on the average controlled burning from 1990 to 2009, the minimum historical level for wildfire and the area of planted forest under *Forest management* in 2009 to estimate nitrous oxide (N_2O) emissions from drained organic soils associated with *Forest management*.

Controlled burning

Emissions from the burning of pre-1990 planted forest harvest residues are now included. The harvest rate is as per the FMRL, and the proportion burned is that applied to the LULUCF category *Forest land remaining forest land* during the first commitment period of the Kyoto Protocol.

Burning of residues associated with conversions of pre-1990 natural forest to pre-1990 planted forest is included. It is assumed to occur at the same rate as reported during the first commitment period.

Wildfire emissions

Wildfires are hard to predict and are influenced by inter-annual climatic conditions and regional drought. To estimate emissions from wildfire, the default methodology described in section 2.3.9.6 of the Kyoto Protocol Supplement (IPCC, 2014) has been applied:

> the value of the mean [of natural disturbance time series data] plus two times the standard deviation is calculated using the entire time series of data in the calibration period. Any outlier value (ie above mean plus two times the standard deviation) is removed. This process is repeated until there are no outliers.

The default method calibration period has been applied between 1990 and 2009. This approach is taken to be consistent with New Zealand's background level of natural disturbance.

Nitrous oxide emissions

It is assumed that there are no N_2O emissions from fertilisation of forests within the FMRL. These are minor and captured within the Agriculture sector.

In the 2022 submission, New Zealand has reported on N_2O emissions, as a result of oxidation of organic matter, from the drainage of organic soils for *Forest management.* Emissions are estimated following the methodology outlined in the 2006 IPCC Guidelines (IPCC, 2006) and described in chapter 6, section 6.10.2. As the FMRL assumes no deforestation in pre-1990 forest, the area of drained organic soils under *Forest management* is assumed to remain constant through the commitment period at the area reported in 2009.

Natural disturbance

Emissions from natural disturbance events were not originally considered in the calculation of the 2011 FMRL. New Zealand has reported its intention to apply the natural disturbance provision and, for *Forest management*, the background level has been set using the default method described in section 2.3.9.6 of the Kyoto Protocol Supplement (IPCC, 2014). This is included in the estimate of the non-carbon emissions as described above.

However, emissions from, and associated with, salvage logging cannot be excluded from accounting during the second commitment period.[10] This means that, when developing the natural disturbance background level, historical emissions from natural disturbances should exclude these emissions. New Zealand has not excluded these emissions from the historical data used to calculate its background level of natural disturbance emissions under its technically corrected FMRL. If New Zealand applies the provision to exclude emissions from natural disturbances from its accounting, the background level will then be adjusted to remove these salvage logging emissions.

Pre-1990 planted forest

A technical correction has been made to ensure the yield tables used for pre-1990 planted forest are consistent with the yield tables used to calculate carbon stock and stock change for *Forest management* in the 2022 submission. This includes the application of two

10 Paragraph 33(c) of annex to Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, p 18.

period-specific yield tables, one for stands planted before 1990 and one for stand planted from 1990 onwards.

The area of pre-1990 planted forest from 2010 to 2020 in the $FMRL_{corr}$ is constant and consistent with the area under *Forest management* reported in 2009.

Pre-1990 natural forest

Emissions and removals by pre-1990 natural forest were not included in the 2011 FMRL submission. Because pre-1990 natural forest is now included in New Zealand's reporting of emissions for *Forest management* land, a technical correction is required. A technical correction was made to include net emissions from pre-1990 natural forest, which includes:

1. an emission factor, using an annual rate of carbon stock change that is consistent with that reported for pre-1990 natural forest from 1990 to 2009 in the 2022 submission
2. the area of pre-1990 natural forest in 2010 to 2020 in the $FMRL_{corr}$ that is consistent with the area under *Forest management* reported in 2009.

Harvested wood products

Emissions and removals for the *Harvested wood products* pool were not included in the 2011 FMRL submission. The technical correction for the final submission of the 2013 to 2020 period uses the same spreadsheet model as that used for New Zealand's *Forest management* reporting. This uses the same underlying emission factor and activity data from 1990 to 2009 as used for *Forest management* in this submission. A different set of activity data, described in more detail below, from 2013 to 2020 is determined to represent a business-as-usual projection for the $FMRL_{corr}$. The technical correction made reflects that no government policies were either in place, or being planned, that would increase wood use and/or domestic production between 2013 and 2020.

To estimate emissions from *Harvested wood products* associated with *Forest management* from 2013 to 2020, two assumptions were made to estimate business-as-usual activity.

1. Domestic processing capacity and production of products would remain constant.
2. Projected increases in harvest volume would result in the excess logs being exported as raw products.

The basis for these assumptions was that any change in domestic processing capacity would reflect a change in *Forest management*. The activity data for *Harvested wood products* in the $FMRL_{corr}$ were then calculated.

Projecting total roundwood production

The annual AGB projected to be removed as merchantable timber on harvest is estimated from the $FMRL_{corr}$ projection for pre-1990 planted forests. The projected AGB removals from 2013 to 2020 were then converted to roundwood volume. The conversion of AGB removed on harvest to roundwood volume is based on the average annual ratio of these statistics from 1990 to 2009. The roundwood volume from 1990 to 2009 is sourced from the Ministry for Primary Industries (Ministry for Primary Industries, 2021), and is consistent with the estimate for *Harvested wood product*s emissions for this submission.

The ratio of estimated AGB removals to roundwood volume was used, rather than simply converting carbon to volume based on a known carbon fraction, because the estimated AGB removed on harvest does not consistently match estimated roundwood production from 1990 to 2009 (see figure A3.2.10, appendix A.3.2.5 for more details).

Between 1990 and 2009, the estimated AGB removed from harvesting planted forests tends to exceed the estimated roundwood production (Ministry for Primary Industries, 2021) over this period (see figure A3.2.10, appendix A.3.2.5). As a result, if AGB losses from projected harvesting in the $FMRL_{corr}$ were converted to roundwood volume based on a known carbon fraction, this would likely overpredict the roundwood volume used to create *Harvested wood products* in the $FMRL_{corr}$, relative to the business-as-usual activity observed over the reference period (1990 to 2009).

Projecting domestic production of Harvested wood products

The activity data for *Harvested wood products* processed domestically in New Zealand over the 2013 to 2020 period are estimated to be the same as the annual average from 2000 to 2009. This period was considered to be representative of New Zealand's business-as-usual processing of *Harvested wood products*. The annual average production over this period was calculated for each individual semi-finished wood product category and for total roundwood volume processed domestically.

Projecting export production of Harvested wood products

Export production of *Harvested wood products* is calculated from an estimated volume of export roundwood (as described in chapter 11, section 11.3.6). Export roundwood production for the $FMRL_{corr}$ is calculated as the projected total roundwood production minus the projected roundwood volume processed domestically.

The inclusion of exported *Harvested wood products* is in line with paragraph 27 of Decision 2/CMP.7. It follows the methodology provided in table 12.1, chapter 12, volume 4 of the 2006 IPCC Guidelines (IPCC, 2006).

Harvested wood products originating from natural forests

Harvested wood products from pre-1990 natural forest is not included in the $FMRL_{corr}$. The volume produced from the harvesting of pre-1990 natural forests is less than 0.1 per cent of New Zealand's total harvest volume (Ministry for Primary Industries, 2015).

A5.1.3 Technical corrections and their impact

The impact of the technical corrections made in the 2016, 2019, 2021 and 2022 submissions to the original FMRL is summarised in table A5.1.2.

Table A5.1.2 Summary of the technical corrections to the FMRL

	Emissions (Mt CO_2-e yr^{-1})
FMRL	**11.150**
Technical corrections	
Pre-1990 planted forest	–11.627
Non-carbon (including natural disturbance)	0.077
Pre-1990 natural forest	–1.442
Harvested wood products	–12.497
Sum of technical corrections	**–25.489**
$FMRL_{corr}$	**–14.339**

Note: FMRL = forest management reference level; $FMRL_{corr}$ = technically corrected forest management reference level.

Figure A5.1.2 provides a breakdown of the various components of the technical corrections over the time series.

Figure A5.1.2 Technical corrections to the FMRL by category

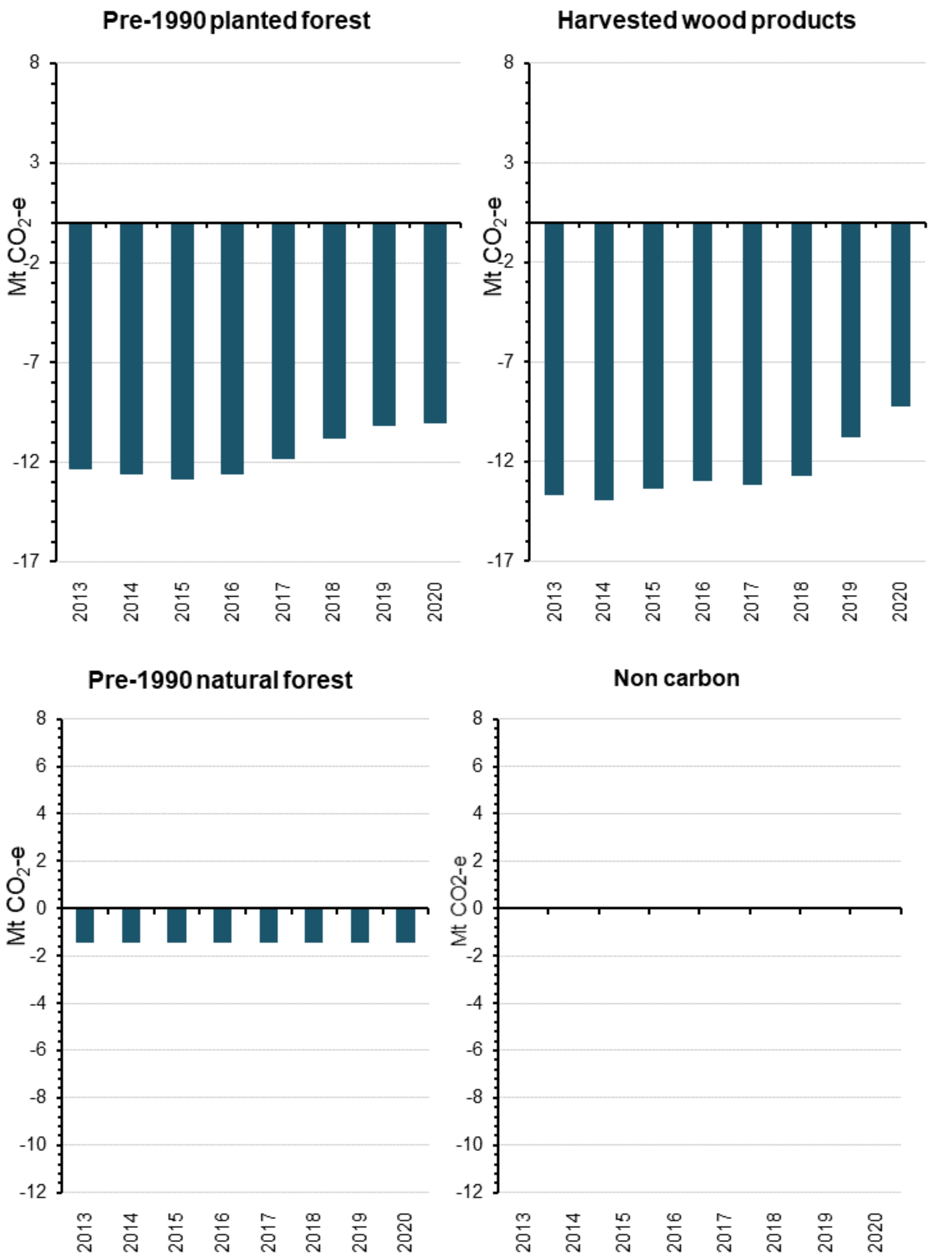
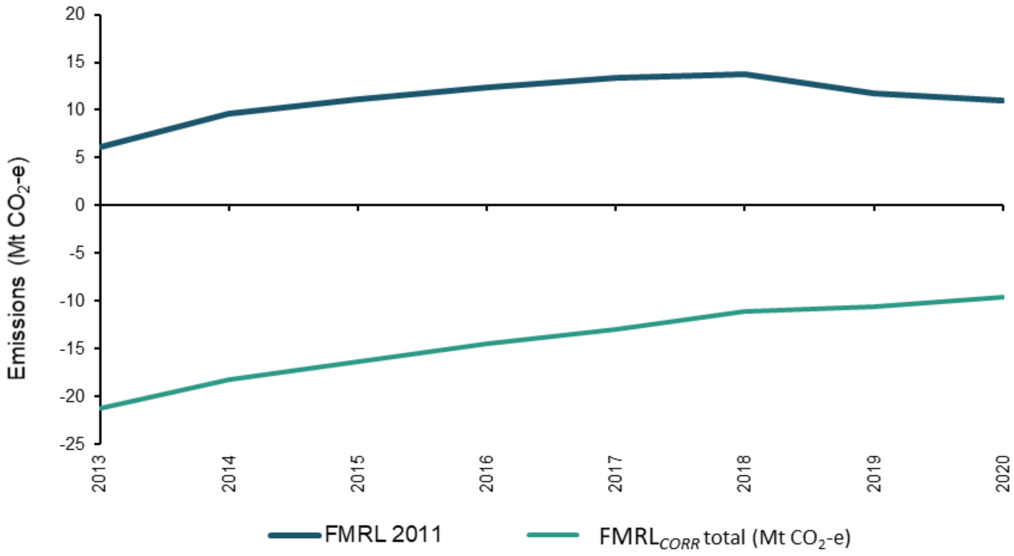


Figure A5.1.3 provides a comparison of recalculated estimates with previous estimates. This illustrates the time-series consistency of the estimates.

Figure A5.1.3 Comparison of the 2011 FMRL and total of technical corrections from 2013 to 2020



Note: FMRL = forest management reference level; $FMRL_{corr}$ = technically corrected forest management reference level.

A5.2 Natural disturbance

New Zealand has chosen to apply the default method described in section 2.3.9.6 of the Kyoto Protocol Supplement (IPCC, 2014) for calculating its background level of natural disturbances for both *Afforestation and reforestation* and *Forest management*. This method has been applied following ERT recommendation KL.10, 2019 (UNFCCC, 2019).

Types of natural disturbances New Zealand intends to exclude from the accounting are:

- wildfires
- invertebrate and vertebrate pests and diseases
- extreme weather events
- geological disturbances.

In all cases except fire, New Zealand assumes a zero baseline between 1990 and 2009. While other natural disturbance events occurred throughout the calibration period, assumptions were made for the purposes of calculating the background level.

For planted forests reported under *Afforestation and reforestation* and *Forest management*, salvage logging is considered to take place in all disturbed forests.

In the case of pre-1990 natural forests, the ground plot measurement programme captures emissions from natural disturbances implicitly, and the emissions from natural disturbance events, apart from wildfires, cannot be separated from other disturbance events. The stock change estimates reported for natural forests include background levels of small-scale natural disturbance events.

Only direct oxidation of biomass in wildfires is considered for the purposes of calculating a background level of natural disturbance for both *Afforestation and reforestation* and *Forest management* land, regardless of forest type. The data used are as reported under the UNFCCC for the period 1990 to 2009 (see chapter 6, section 6.10.8).

A5.2.1 Afforestation and reforestation

New Zealand may choose to apply the provision for the treatment of natural disturbance emissions to its *Afforestation and reforestation* accounting (Ministry for the Environment, 2015). Due to the nature of *Afforestation and reforestation* accounting and reporting methods, the background level of carbon dioxide emissions from natural disturbance is already captured implicitly within the reported estimates. New Zealand separately estimates and reports the non-carbon emissions from natural disturbances. The background level has been calculated using the default method described in section 2.3.9.6 of the Kyoto Protocol Supplement (IPCC, 2014). However, both the post-1989 forest area and the carbon stock increase during the calibration period. To account for the annual change, background level for the calibration period is calculated as a proportion of the post-1989 forest estate. This proportion is then multiplied by the carbon stock in post-1989 forest for each year in the reporting period (2013 to 2020). This approach provides the background level and corrects for the increasing area and age (and therefore carbon stock exposed to natural disturbance) in post-1989 forests.

The *Afforestation and reforestation* background level for 2020 was 2.54 kilotonnes carbon dioxide equivalent (kt CO_2-e).

Avoiding the expectation of net credits or net debits for the application of the natural disturbance provision: Afforestation and reforestation

The background level is calculated using the default methodology described in section 2.3.9.6 of the Kyoto Protocol Supplement (IPCC, 2014). The proportion from the calibration period is then multiplied by the carbon stock in post-1989 forest for each year in the reporting period (2013 to 2020). This approach is taken for the following reasons.

- A trend is observed in natural disturbance emissions during the calibration period for *Afforestation and reforestation*. Emissions from natural disturbances have been increasing throughout the calibration period as the age of these forests and, therefore, biomass increase through time. This trend has continued during the second commitment period. The calibration period was used to obtain an annual emissions value by proportion of carbon stocks and then used to calculate the background level for the 2013 year onwards, based on the carbon stocks of *Afforestation and reforestation* lands in each year.
- Gross:net accounting applies to *Afforestation and reforestation* activities. Emissions from natural disturbances occurring in any year of the commitment period, which fall below the background level, are not excluded from the accounting. Emissions from natural disturbances that are greater than the background level in any year of the commitment period are able to be excluded from the accounting if a Party chooses.
- If emissions from natural disturbances are greater than the background level, they can be excluded from the accounting and there is no expectation of net debits arising. If emissions are less than the background level in any year of the commitment period, all emissions from natural disturbance will still be accounted for. There is no expectation of net debits in this scenario. Under gross:net accounting for *Afforestation and reforestation* activities, it would not be possible to expect net credits when applying this approach to excluding the emissions from natural disturbances.

A5.2.2 Forest management

The background level of natural disturbance for *Forest management* was calculated as 9.34 kt CO_2-e.

Avoiding the expectation of net credits or net debits for the application of the natural disturbance provision: Forest management

The background level has been calculated using the default methodology described in section 2.3.9.6 of the Kyoto Protocol Supplement (IPCC, 2014). Using this method, the expectation of net credits or net debits for the application of the natural disturbance provision is avoided for the following reasons.

- There is no observed trend in natural disturbance emissions during the calibration period for *Forest management* and therefore none can be expected during the second commitment period.
- Any emissions from natural disturbances during the commitment period that fall below the background level are not excluded from the accounting. During the commitment period, emissions from natural disturbances that are above the background level are, subject to New Zealand's discretion, able to be excluded from the accounting.
- The accounting for *Forest management* is against a projected business-as-usual FMRL. The background level is included implicitly within the FMRL, and any emissions greater than the background level can be excluded from the accounting.

A5.3 Carbon equivalent forests

Information on CEF is provided in aggregated form in CRF table 4(KP-I)B.1.2. Details of each application that makes up the reported estimates are provided in table A5.3.1.

Table A5.3.1 Breakdown of carbon equivalent forests by domestic scheme application from 2014 to 2020

Scheme ID	Management type	2014	2015	2016	2017	2018	2019	2020
CEF – 2	Newly established (ha)	–	–	–	302.95	–	–	–
	Harvested and converted (ha)	5.70	62.70	148.37	56.57	27.28	–	–
	Net change (tC)	–1.22	–13.47	–31.84	–18.13	–7.14	0.35	0.61
CEF – 3	Newly established (ha)	–	–	189.93	–	247.19	–	–
	Harvested and converted (ha)	42.96	373.95	1.43	–	–	–	–
	Net change (tC)	–9.25	–80.90	–0.14	0.19	0.11	0.36	0.90
CEF – 4	Newly established (ha)	–	–	61.70	–	–	–	–
	Harvested and converted (ha)	–	–	–	24.44	–	–	–
	Net change (tC)	–	–	–0.03	–6.57	0.02	0.08	0.21
CEF – 8	Newly established (ha)	–	–	54.82	–	–	–	–
	Harvested and converted (ha)	–	–	53.21	–	–	–	–
	Net change (tC)	–	–	–11.61	0.01	0.04	0.09	0.20
CEF – 9	Newly established (ha)	–	–	26.15	–	–	–	–
	Harvested and converted (ha)	–	4.01	19.49	–	–	–	–
	Net change (tC)	–	–0.86	–4.20	0.00	0.02	0.04	0.10
CEF – 11	Newly established (ha)	–	–	–	771.43	992.04	–	–
	Harvested and converted (ha)	3.36	76.81	409.17	488.34	235.11	9.37	24.61
	Net change (tC)	–0.74	–16.57	–88.29	–132.30	–63.38	–2.00	–4.84

Scheme ID	Management type	2014	2015	2016	2017	2018	2019	2020
CEF – 12	Newly established (ha)	–	–	168.21	–	–	–	–
	Harvested and converted (ha)	–	–	167.54	–	–	–	–
	Net change (tC)	–	–	–36.13	0.03	0.13	0.27	0.63
CEF – 13	Newly established (ha)	–	–	111.53	–	–	–	–
	Harvested and converted (ha)	–	1.61	106.49	–	–	–	–
	Net change (tC)	–	–0.35	–22.94	0.02	0.08	0.18	0.41
CEF – 14	Newly established (ha)	–	–	–	153.61	–	–	–
	Harvested and converted (ha)	–	2.42	148.44	–	–	–	–
	Net change (tC)	–	–0.53	–32.34	–0.11	0.03	0.12	0.25
CEF – 15	Newly established (ha)	–	–	–	194.01	–	–	–
	Harvested and converted (ha)	–	–	47.83	89.18	–	–	–
	Net change (tC)	–	–	–10.43	–25.70	0.07	0.18	0.35
CEF – 17	Newly established (ha)	–	–	–	8.61	–	–	–
	Harvested and converted (ha)	–	–	6.60	–	–	–	–
	Net change (tC)	–	–	–1.44	–0.08	0.00	0.01	0.02
CEF – 18	Newly established (ha)	–	–	–	–	130.00	–	–
	Harvested and converted (ha)	–	5.00	124.80	–	–	–	–
	Net change (tC)	–	–1.09	–27.24	0.09	–0.27	0.03	0.11
CEF – 19	Newly established (ha)	–	–	–	–	114.81	–	–
	Harvested and converted (ha)	–	1.32	4.87	103.99	–	–	–
	Net change (tC)	–	–0.29	–1.06	–27.82	–0.11	0.02	0.09
CEF – 20	Newly established (ha)	–	–	–	14.47	–	–	–
	Harvested and converted (ha)	–	7.69	–	–	–	–	–
	Net change (tC)	–	–1.68	0.01	–0.06	–0.00	0.01	0.02
CEF – 21	Newly established (ha)	–	–	–	180.17	–	–	–
	Harvested and converted (ha)	–	1.78	67.81	104.54	–	–	–
	Net change (tC)	–	–0.38	–14.57	–28.02	0.03	0.14	0.29
CEF – 24	Newly established (ha)	–	–	–	22.47	–	–	–
	Harvested and converted (ha)	–	–	–	17.89	–	–	–
	Net change (tC)	–	–	–	–4.81	0.00	0.01	0.03
CEF – 25	Newly established (ha)	–	–	–	–	279.64	–	–
	Harvested and converted (ha)	–	–	–	79.63	–	5.24	8.98
	Net change (tC)	–	–	–	–21.31	–0.87	–1.44	–2.28
CEF – 27	Newly established (ha)	–	–	–	37.96	21.15	–	–
	Harvested and converted (ha)	–	–	53.03	–	–	–	–
	Net change (tC)	–	–	–11.39	–0.12	–0.07	0.03	0.08
CEF – 31	Newly established (ha)	–	–	–	–	10.19	–	–
	Harvested and converted (ha)	–	–	–	7.17	–	–	–
	Net change (tC)	–	–	–	–1.92	–0.04	0.00	0.01
CEF – 35	Newly established (ha)	–	–	–	–	–	9.72	–
	Harvested and converted (ha)	–	6.11	–	–	–	–	–
	Net change (tC)	–	–1.33	0.00	0.00	0.00	–0.00	0.00
CEF – 36	Newly established (ha)	–	–	–	–	–	225.10	–
	Harvested and converted (ha)	–	–	104.12	59.62	32.65	–	–
	Net change (tC)	–	–	–22.73	–15.88	–8.63	0.01	0.03

Scheme ID	Management type	2014	2015	2016	2017	2018	2019	2020
CEF – 38	Newly established (ha)	–	–	–	–	–	11.35	–
	Harvested and converted (ha)	–	–	–	10.37	–	–	–
	Net change (tC)	–	–	–	–2.77	0.01	–0.10	0.01
CEF – 39	Newly established (ha)	–	–	–	–	–	135.53	–
	Harvested and converted (ha)	–	–	7.58	103.48	–	–	–
	Net change (tC)	–	–	–1.66	–27.68	0.07	–0.39	0.03
CEF – 40	Newly established (ha)	–	–	–	–	–	36.57	–
	Harvested and converted (ha)	–	–	–	36.08	–	–	–
	Net change (tC)	–	–	–	–9.65	0.02	–0.27	0.02
CEF – 41	Newly established (ha)	–	–	–	–	–	4.58	–
	Harvested and converted (ha)	–	–	–	–	6.78	–	–
	Net change (tC)	–	–	–	–	–1.81	–0.00	0.00
CEF – 42	Newly established (ha)	–	–	–	–	–	86.55	–
	Harvested and converted (ha)	–	–	–	–	82.96	–	–
	Net change (tC)	–	–	–	–	–22.20	–0.17	0.02
CEF – 43	Newly established (ha)	–	–	–	–	–	49.57	–
	Harvested and converted (ha)	–	–	–	–	–	41.78	–
	Net change (tC)	–	–	–	–	–	–11.43	0.01
CEF – 44	Newly established (ha)	–	–	–	–	–	20.75	–
	Harvested and converted (ha)	–	–	–	–	19.63	–	–
	Net change (tC)	–	–	–	–	–5.25	0.00	0.00
CEF – 45	Newly established (ha)	–	–	–	–	–	–	39.84
	Harvested and converted (ha)	–	–	–	38.37	–	–	–
	Net change (tC)	–	–	–	–10.27	0.02	0.02	0.00
CEF – 47	Newly Established (Ha)	–	–	–	–	–	–	62.62
	Harvested and Converted (Ha)	–	–	–	7.15	11.84	43.93	–
	Net change (tC)	–	–	–	–1.91	–3.16	–11.74	–0.02
CEF – 49	Newly established (ha)	–	–	–	–	–	–	90.00
	Harvested and converted (ha)	–	–	4.56	1.60	82.89	–	–
	Net change (tC)	–	–	–1.00	–0.43	–22.17	0.06	–0.02
CEF – 51	Newly established (ha)	–	–	–	–	–	–	32.06
	Harvested and converted (ha)	–	–	–	–	–	–	29.17
	Net change (tC)	–	–	–	–	–	–	–7.82
TOTAL	**Newly established (ha)**	**–**	**–**	**612.34**	**1,685.68**	**1,795.02**	**579.73**	**224.52**
	Harvested and converted (ha)	**52.02**	**543.40**	**1,475.36**	**1,228.39**	**499.14**	**100.32**	**62.76**
	Net change (tC)	**–11.22**	**–117.44**	**–319.02**	**–335.17**	**–134.41**	**–25.53**	**–10.57**

Note: CEF = carbon equivalent forest.

Annex 5: References

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Annex 6: Additional information on the inventory system and completeness

A6.1 Quality assurance and quality control processes

Quality assurance and quality control (QA/QC) processes have a significant role in the preparation of the inventory, to ensure the core principles of transparency, accuracy, completeness, comparability and consistency are achieved. Table A6.1.1 describes the main QA/QC processes used in the preparation of the inventory. These processes are under continual review and improvement, to ensure they are fit for purpose.

Table A6.1.1 Quality assurance and quality control processes used in preparation of the inventory

ID	QA/QC process or activity description
QA file	All external reviews of the whole or part of the inventory are documented in the QA file. Reviews are performed by qualified personnel, and the review records are included in the submission of the inventory to the United Nations Framework Convention on Climate Change. These reviews help identify improvements to the inventory.
QC 1	Planned recalculations and improvements are approved by the reporting governance group that oversees all climate change reporting by the New Zealand Government. The role of this group is further described in chapter 1.
QC 2	Planned improvements are peer reviewed before being implemented when they affect the emission factor, parameter, methodology or activity data source. Some sectors have a dedicated panel of experts who review improvements.
QC 3	Tier 1 checklist QC sheets are completed to ensure transparency, accuracy, completeness, comparability and consistency principles are met. Examples are included in the submission of the inventory.
QC 4	The chapter text for each sector is peer reviewed and follows the checklist provided, to ensure that the peer review is comprehensive and consistent.
QC 5	Recalculations that exceed a certain threshold (see figure A6.1.1) are analysed and clearly documented. This includes changes resulting from planned improvements, errors, recommendations from the expert review team, and changes to guidelines.
QC 7	All sectors in the inventory are approved by the relevant member of the reporting governance group that oversees all international climate change reporting by the New Zealand Government before being submitted to the National Inventory Compiler.
QC 10	Common reporting format QC tools identify any potential issues with the data and are used to ensure the data integrity standards are met.
Sector submission checks	Sector submissions are checked against the data integrity standards and chapter formatting standards by the inventory agency before sector submission. Any issues must be resolved before submitting. This enables the remainder of the inventory compilation to proceed smoothly because quality is assured.

Figure A6.1.1 shows how these QA/QC processes align with the overall preparation of the inventory.

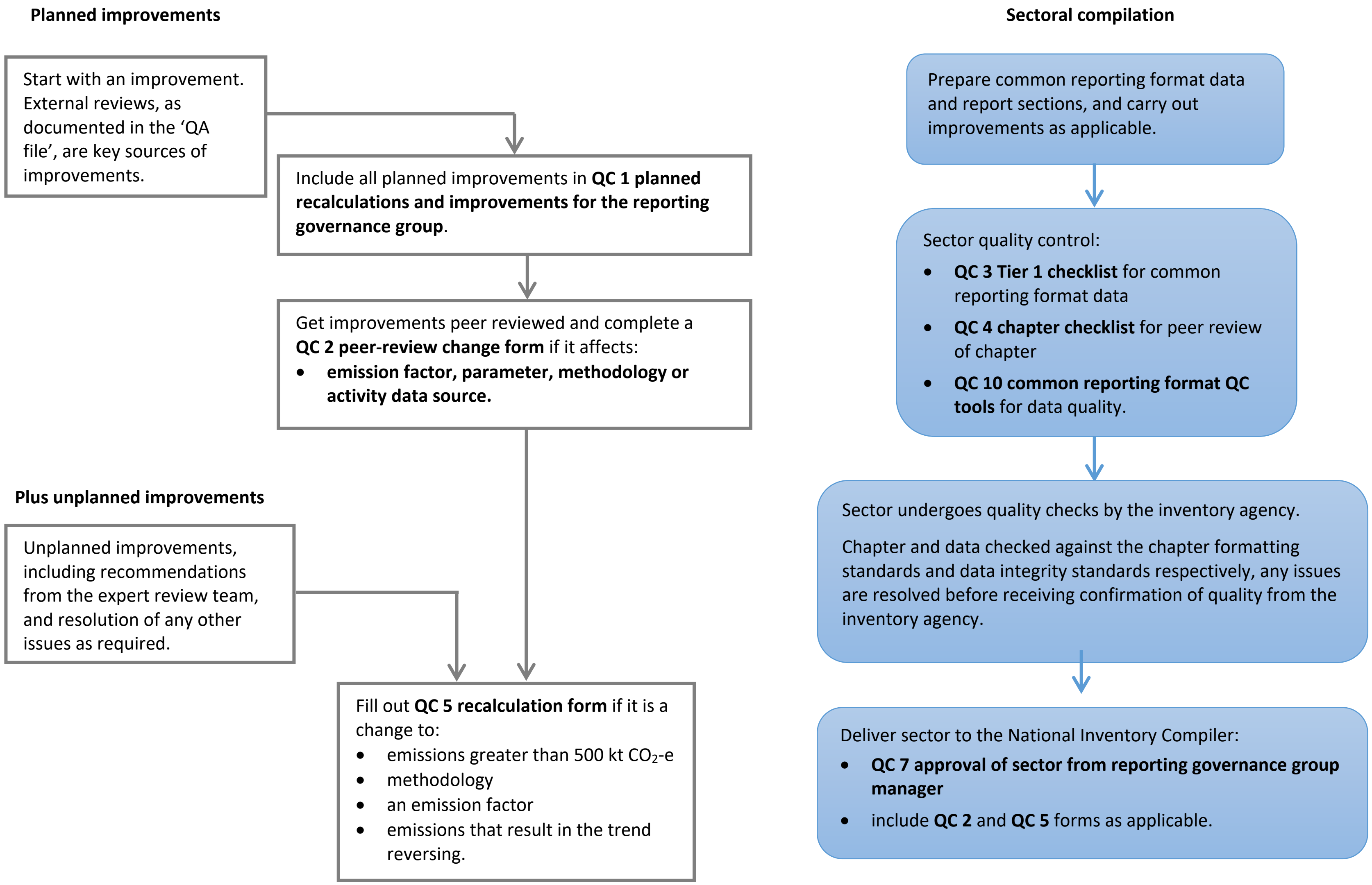
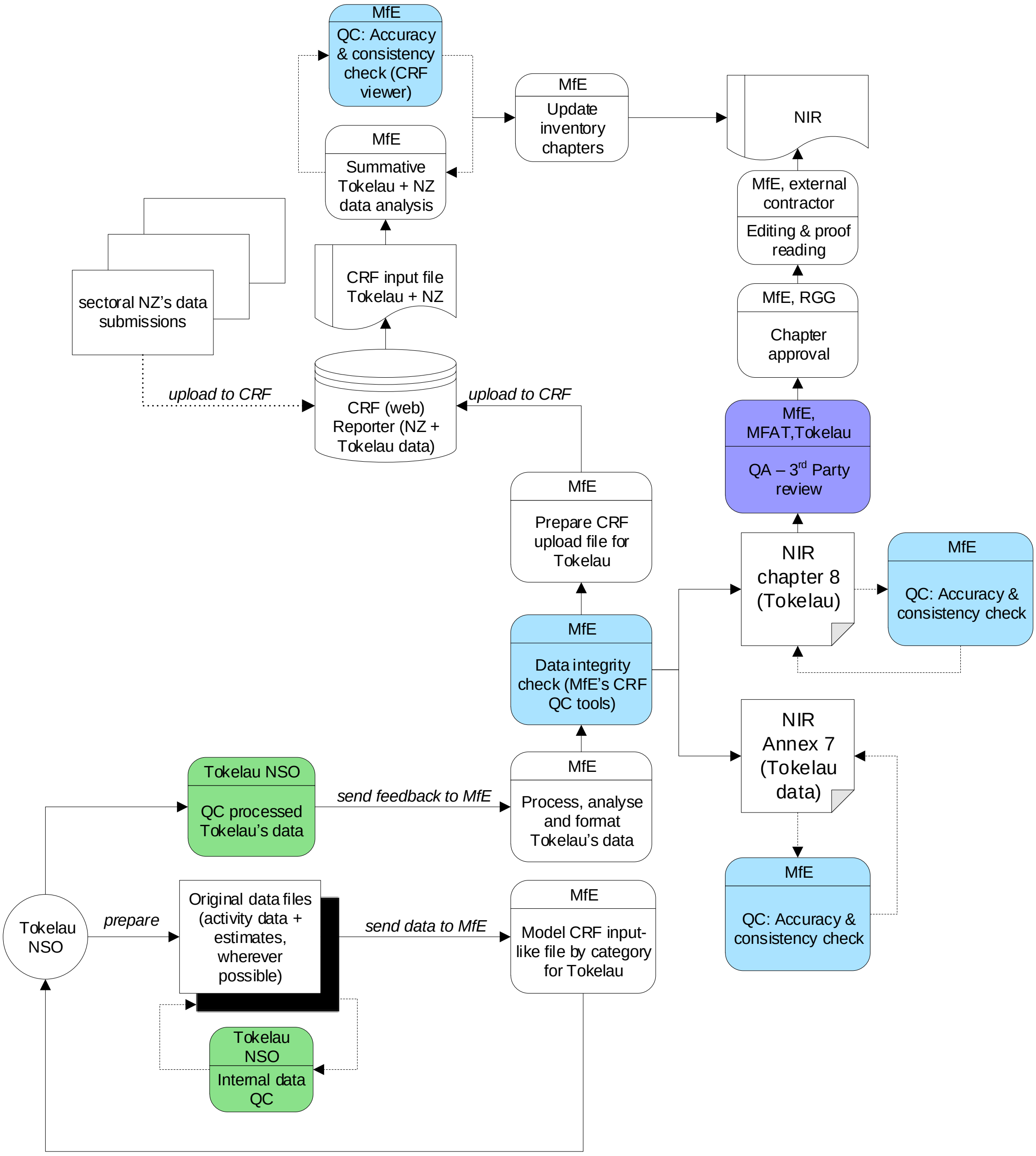


Figure A6.1.1 How the quality assurance and quality control processes and products align with the preparation of the inventory

Figure A6.1.2 presents an overview of the compilation process for Tokelau, and its integration into New Zealand's inventory. It also shows where QA/QC steps are applied.

Figure A6.1.2 Data processing, quality assurance and quality control processes applied to the inventory data from Tokelau and its integration into New Zealand's inventory



CRF	Common reporting format
MFAT	Ministry of Foreign Affairs and Trade (New Zealand)
MfE	Ministry for the Environment (New Zealand)
(green)	QA/QC procedures performed by Tokelau NSO
(light blue)	QA/QC procedures performed by MfE
(purple)	QA/QC procedures performed by third parties
NIR	National inventory report
NSO	National Statistics Office (Tokelau)
QA/QC	Quality assurance and quality control
RGG	Reporting Governance Group

A6.2 General assessment of completeness

A6.2.1 Emissions reported as ‘NE’ (not estimated)

According to the United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines (UNFCCC, 2013), the notation key ‘NE’ (not estimated) signifies that emissions and/or removals occur but have not been estimated or reported. ‘NE’ can be applied for the following reasons.

- If emissions of a gas from a category are insignificant, that is, they should not exceed 0.05 per cent of the national total greenhouse gas (GHG) emissions, and do not exceed 500 kilotonnes carbon dioxide equivalent (kt CO_2-e) (paragraph 37(b) of the UNFCCC reporting guidelines).
- The total national aggregate of estimated emissions for all gases and categories considered insignificant shall remain below 0.1 per cent of the national total GHG emissions (paragraph 37(b) of the UNFCCC reporting guidelines).
- When an activity occurs in the Party but the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC, 2006) do not provide methodologies to estimate emissions and removals (footnote 6 of the UNFCCC reporting guidelines (UNFCCC, 2013)). If this is the case, the category is considered to be non-mandatory, providing the emissions from the category have not been reported previously.

The UNFCCC reporting guidelines also state that, once emissions from a specific category have been reported in a previous submission, emissions from this specific category shall be reported in subsequent GHG inventory submissions (UNFCCC, 2013).

New Zealand’s gross emissions were 78,778.4 kt CO_2-e in 2020. The threshold of 0.1 per cent for New Zealand’s 2022 submission is 78.8 kt CO_2-e and the threshold of 0.05 per cent is 39.4 kt CO_2-e. Both values are below 500 kt CO_2-e.

Table A6.2.1 summarises New Zealand’s direct GHG emissions reported as ‘NE’ in the 2022 submission.

Table A6.2.1 Summary of ‘NE’ (not estimated) entries in 2022 submission

CRF category code	Category	Gas	Explanation
Energy			
1.B.1.a.1.iii	Abandoned underground mines	CO_2, CH_4	The current assessment is that emissions from this category do not occur in the North Island of New Zealand and are not estimated for the South Island. Because the historical information is not available, New Zealand does not have any reliable information on activities related to emissions from abandoned mines to reliably report on. A project focusing on collating and digitising mine data for the South Island commenced in December 2019 and is ongoing: progress over 2021 has been reported in section 3.4.1. Further data collection and processing is still required before it will be usable for a meaningful assessment of fugitive emissions. To enable a realistic estimate of emissions to be made, further information is required: a) elevation data to determine likely flooded or unflooded status and b) data on mine size to be used in applying a cut-off threshold. The intention is to complete this work in time for the 2023 submission.

CRF category code	Category	Gas	Explanation
1.B.2.a.5	Distribution of oil products	CO_2, CH_4	According to paragraph 37(b) of the United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines (Decision 24/CP.19), this category is not mandatory: the 2006 IPCC Guidelines do not provide the default Intergovernmental Panel on Climate Change (IPCC) emission factor for calculating Tier 1 estimates of methane (CH_4) emissions from the distribution of refined oil products. New Zealand has not reported emission estimates from this category in previous submissions.
1.B.2.b.3	Processing	CO_2, CH_4	Fugitive emissions of carbon dioxide (CO_2) and CH_4 have not been formally estimated, although a rough estimate of the likely level of emissions indicates that they are insignificant. While emissions from the Kapuni Gas Treatment Plant may include traces of CH_4, the level of these emissions has been determined to be insignificant in comparison with national emissions: a conservative estimate (using default emission factors from the 2006 IPCC Guidelines) gives nearly 1.5 kilotonnes carbon dioxide equivalent (kt CO_2-e) per year. CH_4: 625 Mm^3 (Kapuni field production) * 9.7e-5 * 25 = 1.5 kt CO_2-e. The conservative estimated value is below 0.05 per cent of New Zealand's gross emissions. This would keep the national total aggregate of estimated emissions for all gases and categories considered insignificant below 0.1 per cent of the national total greenhouse gas emissions, which is in line with paragraph 37(b) of the UNFCCC reporting guidelines. Carbon dioxide from gas processing is mostly associated with direct venting through a stack and, therefore, is reported under 1.B.2.c.1, as recommended in the 2017 assessment review report. However, there is a possibility of the presence of trace amounts of CO_2 from processing due to leakage, which is estimated to be no higher than 0.1 per cent of vented CO_2. A conservative estimate of 0.1 per cent of vented CO_2 from all categories is 0.26 kt, which is below 0.05 of the gross emissions and thus can be considered insignificant.
Agriculture			
3.A.4 (for both New Zealand and Tokelau)	Poultry	CH_4	According to paragraph 37(b) of the UNFCCC reporting guidelines, this category is not mandatory: the 2006 IPCC Guidelines state (page 10.27, vol 4-2) that the Tier 1 method for estimating CH_4 emissions from enteric fermentation for poultry is not developed. Also, table 10.10 (page 10.28, vol 4-2) indicates that there is insufficient research to establish a CH_4 emission factor for poultry for either developed or developing countries.
3.B.2.5	Indirect N_2O emissions	N_2O	According to footnote 6 in paragraph 37(b) of the UNFCCC reporting guidelines (Decision 24/CP.19), this category is not mandatory for reporting. The 2006 IPCC Guidelines for determining indirect nitrous oxide (N_2O) emissions do not provide a methodology for estimating emissions from leaching and run-off. In addition, indirect N_2O emissions from leaching and run-off are insignificant in New Zealand, because almost all livestock are kept outdoors all year around on pasture.
3.B.2.5	N_2O emissions per MMS[11]	N_2O	Direct N_2O emissions from anaerobic lagoons (dairy and swine) and daily spread (swine) are reported under *Agricultural soils*. The 2006 IPCC Guidelines assume that negligible direct N_2O emissions occur in anaerobic lagoons and daily spread, and only occur once the stored effluent is spread onto agricultural soil. For more information, see chapter 5, section 5.3.2 (Direct nitrous oxide emissions from manure management) and section 5.5.2 (Urine and dung deposited by grazing animals) of the National Inventory Report. According to footnote 6 in paragraph 37(b) of the UNFCCC reporting guidelines (Decision 24/CP.19), this category is not mandatory for reporting.

11 MMS stands for a manure management system (see chapter 5).

CRF category code	Category	Gas	Explanation
3.D.1.2.c	Other organic fertilisers applied to soils	N_2O	Emissions from 'Other organic fertilisers applied to soils' are not estimated due to their insignificance, as defined in accordance with the UNFCCC reporting guidelines (Decision 24/CP.19, paragraph 37(b)). Emissions are roughly estimated to be 20 kt CO_2-e (van der Weerden et al., 2014). Emissions are below the threshold of 0.05 per cent of the national total greenhouse gas emissions and do not exceed 500 kt CO_2-e.
3.I	Other carbon-containing fertilisers	CO_2	According to the UNFCCC reporting guidelines (Decision 24/CP.19, paragraph 37), this category is not mandatory because the 2006 IPCC Guidelines do not provide guidance for reporting on other carbon-containing fertilisers. Other carbon-containing synthetic fertilisers besides limestone, dolomite and urea are not applied to agricultural land in New Zealand.
Land Use, Land-Use Change and Forestry			
4.D.1	Forest land, cropland, grassland and wetlands: Drainage and rewetting and other management of organic and mineral soils	CH_4, N_2O	No methodology is provided in the 2006 IPCC Guidelines for estimating emissions from this source category. According to footnote 6 in paragraph 37(b) of the UNFCCC reporting guidelines (Decision 24/CP.19), this category is not mandatory for reporting.
4.A, 4.B, 4.C	Vegetated wetlands converted to Forest land, Cropland and Grassland	CO_2	No IPCC guidance is provided for calculating Tier 1 estimates of carbon stocks in living biomass for Wetlands. Therefore, with land-use change from Wetlands to other land uses, no carbon stock loss is reported.
4.A, 4.B, 4.C, 4.D	Forest land, Cropland, Grassland and Wetlands: rewetting and other management of organic and mineral soils	CO_2	No methodology is provided in the 2006 IPCC Guidelines for estimating emissions from this source category. According to footnote 6 in paragraph 37(b) of the UNFCCC reporting guidelines (Decision 24/CP.19), this category is not mandatory for reporting.
4.B.1	Cropland remaining cropland/4(V) Biomass burning/ Wildfires/Cropland remaining cropland	CH_4, N_2O	New Zealand does not have sufficient information on biomass burning activities to reliably report on it.
4.B.2	Land converted to cropland/4(V) Biomass burning/ Wildfires/Land converted to cropland	CH_4, N_2O	New Zealand does not have sufficient information on biomass burning activities to reliably report on it.
4.D.1	Wetlands remaining wetlands/4(V) Biomass burning/ Wildfires/Wetland remaining wetland	CH_4, N_2O	According to paragraph 37(b) of the UNFCCC reporting guidelines (Decision 24/CP.19), this category is not mandatory because no IPCC guidance is provided for calculating Tier 1 estimates of carbon stock changes in organic soils for this land use category. New Zealand does not have sufficient information on biomass burning activities to reliably report on it.
Waste			
5.C.2.2.a	Incineration of municipal solid waste	CO_2, CH_4 and N_2O	Around 100–200 rural schools in New Zealand still incinerate their waste production. Estimates indicate this practice emits 0.04 kt CO_2-e per year. NE (not estimated) is used because New Zealand does not have sufficient information regarding the practice of incinerating waste in schools, and the amount is negligible. This is in accordance with paragraph 37(b) of the UNFCCC reporting guidelines (Decision 24/CP.19).
5.D.1 and 5.D.2	Domestic wastewater and Industrial wastewater	Amount of CH_4 flared and for energy recovery	NE (not estimated) is used for activity data, because New Zealand does not have any information regarding the CH_4 flaring in this source category. The amount of CH_4 flared does not contribute to New Zealand's total emissions because it produces biogenic CO_2 (as per the 2006 IPCC Tier 1 methodology provided in table 5D of the common reporting format tables).

The estimate of emissions for all of New Zealand's source categories marked as 'NE' results in 21.8 kt CO_2-e, which is below the 0.1 per cent of the total emissions threshold (78.8 kt CO_2-e).

A6.2.2 Emissions reported as 'IE' (included elsewhere)

According to the UNFCCC reporting guidelines (UNFCCC, 2013), the notation key 'IE' (included elsewhere) signifies that emissions and/or removals for this activity or category are estimated and included in the Inventory but not presented separately for this category.

Table A6.2.2 details where the notation key 'IE' has been used in this submission of the inventory.

Table A6.2.2 Emissions reported using the 'IE' (included elsewhere) notation key

CRF category code	Category	Reported under the following source category:	Notation key explanation
1.A.2.a	Iron and steel – liquid fuels	1.A.2.g.viii – Other – Liquid fuels	Liquid fuels activity data for this category do not exist.
1.A.2.a	Iron and steel – solid fuels	2.C.1 – Iron and steel production	All emissions from the use of coal in this category are included in the Industrial Processes and Product Use sector because the primary purpose of the coal is to produce iron.
1.A.2.f	Non-metallic minerals – biomass	1.A.2.g.viii – Other – Biomass	Activity data for this category do not exist.
1.A.2.g.v	Construction – all fuels	1.A.2.g.iii – Mining	Disaggregated data do not exist.
1.A.3.b.ii–iv	Road transportation (other than 'Cars') – all fuels (other than gasoline and diesel)	1.A.3.b.i – Cars	Disaggregated data do not exist for all years for all fuels.
1.A.4.c.ii–iii	Agriculture/forestry/fishing – Off-road vehicles and other machinery	1.A.4.c.i – Agriculture/ forestry/fishing – Stationary	Agriculture/forestry/fishing has not been disaggregated into stationary, mobile and fishing for some fuels: data are not available.
1.B.2.b.1	Natural gas/exploration	1.B.2.a.1 – Oil exploration	In New Zealand, exploration is not specifically aimed at obtaining oil or gas, that is, oil exploration is not separated from gas exploration by planning, processes, equipment, or resources. Thus, the exploratory wells are drilled without distinction of their purpose, that is, whether the expected outcome is oil, gas, both or none, and there is no reliable way to predict which it would be to estimate proportions of mostly oil and mostly gas wells. In that sense, disaggregated data for oil and gas exploration do not exist. Considering that available emission factors for well drilling and testing also do not distinguish between oil and gas, all emissions from oil and gas exploration are placed in the same category.
1.B.2.c.1.i–ii	Venting/oil and Venting/gas	1.B.2.c.1.iii – Venting/combined	The fields produce both oil and gas and, therefore, are reported as combined. Disaggregated data do not exist.
1.B.2.c.1.i–ii	Flaring/oil and Flaring/gas	1.B.2.c.1.iii – Flaring/combined	The fields produce both oil and gas and, therefore, are reported as combined. Disaggregated data do not exist.

CRF category code	Category	Reported under the following source category:	Notation key explanation
2.A.3	Glass production	2.A.4.b – Other process uses of carbonates/Other uses of soda ash	Carbon dioxide emissions are reported in 2.A.4.b because this aggregates emissions from glass production with other uses of carbonates, due to confidentiality concerns for both glass and aluminium production. A very small number of firms in New Zealand are involved in these activities and use carbonates.
3.A.4	Enteric fermentation/other/buffalo	3.A.1.A – Dairy cattle	A small herd of around 200 buffalo was brought into New Zealand around 2007 for specialised cheese and dairy production. These buffalo are reported within the dairy herd so the notation key 'IE' is used from 2007 onwards.
3.B.1.4 & 3.B.2.4	Manure management/other/ buffalo	3.B.1.A – Dairy cattle 3.B.2.A – Dairy cattle	For both nitrous oxide (N_2O) and methane (CH_4) emissions, the notation key 'NO' (not occurring) is used up to 2006 because no buffalo were recorded in New Zealand before 2007. A small herd of around 200 buffalo was brought into New Zealand around 2007 for specialised cheese and dairy production. See notation key explanation for 3.A.4. For more information, see chapter 5, section 5.1.4 (Minor livestock categories) of this national inventory report.
3.B.2.5	N_2O emissions per MMS[12]	3.D – Agricultural soils	Direct N_2O emissions from anaerobic lagoons (dairy and swine) and daily spread (swine) are reported under *Agricultural soils*.
3.D.1.2.b	Sewage sludge applied to soils	Included under the Waste sector 5.A.1.a	Direct N_2O emissions from sewage sludge are reported under 5.A.1.a in the Waste sector. Sewage sludge activity data are obtained from water treatment industry surveys and do not disaggregate the amount of sludge used for different purposes. Due to the small amount of emissions coming from sewage sludge, further disaggregation of the activity data is considered resource prohibitive. Sewage sludge is a very small source of nitrogen (van der Weerden et al., 2014).
3.E	Prescribed burning of savannas	Biomass burning (table 4(V) of LULUCF), category C Grassland	Prescribed burning of savanna is reported under the Land Use, Land-Use Change and Forestry (LULUCF) sector. See chapter 6, section 6.10.8 (Biomass burning (table 4(V) of LULUCF), category C Grassland).
4.A.1/4(V)	Controlled burning	Forest land remaining forest land	Carbon dioxide emissions are captured by the general carbon stock change calculation if the fire-damaged area is harvested and replanted. If the stand is allowed to grow on but with a reduced stocking, the carbon dioxide (CO_2) emissions are accounted for at the eventual time of harvest.

[12] MMS stands for a manure management system (see chapter 5).

CRF category code	Category	Reported under the following source category:	Notation key explanation
4.A.2	Land converted to forest land	Land converted to forest land	Because New Zealand uses the stock change approach, CO_2 emissions from biomass losses are only reported in years new land is converted to this category, or where there is harvesting of forest in this year. When neither of these things occur the only losses are reported with biomass gains (stock change approach) and IE is reported for biomass losses.
4.A.2/4(V)	Controlled burning/Land converted to forest land Wildfires/Land converted to forest land	Land converted to forest land	Carbon dioxide emissions are captured by the general carbon stock change calculation, if the fire-damaged area is harvested and replanted. If the stand is allowed to grow on but with a reduced stocking, the CO_2 emissions are accounted for at the eventual time of harvest.
4.B.1, 4.B.2, 4C.1, 4C.2	Cropland remaining cropland, land converted to cropland, grassland remaining grassland, land converted to grassland	Cropland remaining cropland, land converted to cropland, grassland remaining grassland, land converted to grassland	New Zealand uses the stock change approach to estimate biomass emissions, therefore, biomass losses are reported with biomass gains and IE is reported.
4.B.1/4(V)	Controlled burning/Cropland remaining cropland	Included under the Agriculture sector	Carbon dioxide and CH_4 emissions from burning of crop stubble are reported in the Agriculture sector.
4.B.1/4(V)	Wildfires/Cropland remaining cropland	Cropland remaining cropland	Any CO_2 emissions from wildfires on non-forest land are likely to be offset by the subsequent carbon gain from the regrowth of biomass, which is also not accounted for. Alternatively, if the wildfire resulted in land-use change, then any CO_2 emissions would be captured by the general carbon stock change calculation that is performed when land is converted to a new land use.
4.B.2/4(V) 4.C.1/4(V) 4.C.2/4(V) 4.D.2/4(V)	Wildfires/Land converted to cropland Wildfires/Grassland remaining grassland Wildfires/Land converted to grassland Wildfires/Land converted to wetlands	Land converted to cropland Grassland remaining grassland Land converted to grassland Land converted to wetlands	Any CO_2 emissions from wildfires on non-forest land are likely to be offset by the subsequent carbon gain from the regrowth of biomass, which is also not accounted for. Alternatively, if the wildfire resulted in land-use change, then any CO_2 emissions would be captured by the general carbon stock change calculation that is performed when land is converted to a new land use.
4.A.1/4(I) 4.D.1/4(I) 4.D.2/4(I) 4.E.1/4(I) 4.E.2/4(I)	Direct N_2O emissions from nitrogen (N) inputs to managed soils Inorganic N fertilisers and Direct N_2O emissions from N inputs to managed soils Organic N fertilisers In the following categories: • Forest land remaining forest land • Wetlands remaining wetlands • Land converted to wetlands • Settlements remaining settlements	Included under the Agriculture sector	New Zealand does not disaggregate data on nitrogen fertiliser by land use, therefore, all N_2O emissions from organic and inorganic fertilisers are reported in the Agriculture sector.

CRF category code	Category	Reported under the following source category:	Notation key explanation
	• Land converted to settlements • Settlements remaining settlements • Land converted to settlements		
4.B.1/4(V)	Controlled burning/Cropland remaining cropland	Included under the Agriculture sector.	All emissions from burning of crop stubble are reported in the Agriculture sector.
4.C.1/4(V) 4.D.1/4(V)	Controlled burning/Grassland remaining grassland Controlled burning/Wetland remaining wetland Wildfires/Wetland remaining wetland	Grassland remaining grassland Wetland remaining wetland Wetland remaining wetland	This is not a significant activity in New Zealand due to the country's temperate climate and rainfall distribution, and any CO_2 emissions from burning on non-forest land are likely to be offset by the subsequent carbon gain from the regrowth of biomass, which is also not accounted for. Alternatively, if the fire resulted in land-use change, then any CO_2 emissions would be captured by the general carbon stock change calculation that is performed when land is converted to a new land use.
4.C.2/4(V) 4.D.2/4(V) 4.E/4(V)	Controlled burning/Land converted to grassland Controlled burning/Land converted to wetlands Biomass burning/Land converted to settlements	Land converted to grassland Land converted to wetlands Land converted to settlements	Carbon dioxide emissions from the controlled burning of land converted to this category are captured by the general carbon stock change calculation that is performed when land is converted to a new land use.
5.D.1	Domestic wastewater	5.A Solid waste	Activity data – sludge amounts are included under solid waste disposal because sludge is disposed to landfill.
5.D.2	Industrial wastewater	5.A Solid waste	Activity data – sludge amounts are included under solid waste disposal because sludge is disposed to landfill.
5.D.2	Industrial wastewater	1.A.2.e Food processing, beverages and tobacco – Biomass	Emissions of CH_4 and N_2O from the combustion of biogas from the Tirau dairy processing plant are reported under 1.A.2.e *Food processing, beverages and tobacco – Biomass.*
Within the Tokelau sector 6, categories 1.A.3.b.i and 1.A.4.c.iii were reported elsewhere	Road transport/Gasoline and diesel oil	Domestic navigation	The number of petrol cars has, until recently, been small in Tokelau (in 2018 only about 40 cars and 30 motorbikes, with an entire road network less than 10 kilometres). Census 2001 and prior record only four registered cars. Aluminium boats are the main means of family transport: there were, on average, about 100 outboard motors travelling both outside and within the large lagoons. Therefore, any petrol use for road transport is far outweighed by Domestic navigation, and is included there.
Within the Tokelau sector 6, category 1.A.4.b is reported elsewhere	Residential (1.A.4.b) liquid fuels	Domestic navigation	Only gas used for cooking is listed here. Amounts of liquid fuel use are miniscule compared with Domestic navigation and are included there.

Annex 6: References

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Van der Weerden A, de Klein C, Kelliher F, Rollo M. 2014. *Reporting to 2006 IPCC Guidelines for N_2O Emissions from Additional Sources of Organic N: Final Report*. MPI Technical Report. Wellington: Ministry for Primary Industries.

Annex 7: Tokelau

A7.1 Emissions estimate data and relevant supporting information by category for Tokelau[13]

Tokelau CRF Table 1.A.1.a: [1. Energy][1.AA Fuel Combustion – Sectoral approach][1.A.1 Energy Industries][1.A.1.a Public Electricity and Heat Production] (Part 1 of 3)

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.1 Energy Industries][1.A.1.a Public Electricity and Heat Production]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Fuel Consumption	TJ	3.268	3.268	3.268	3.268	3.268	3.268	3.268	3.268	3.268	3.268
Liquid fuels	TJ	3.268	3.268	3.268	3.268	3.268	3.268	3.268	3.268	3.268	3.268
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Liquid fuels		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Method											
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CO_2		D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions											
CO_2	kt	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Liquid fuels	kt	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
CH_4	kt	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093

[13] The category names and CRF codes for source categories are consistent with New Zealand's CRF tables. Only the tables that include reported emissions (by value, IE or NE) are included. For explanations and methodological issues, please refer to chapter 8.

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.1 Energy Industries][1.A.1.a Public Electricity and Heat Production]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Liquid fuels	kt	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093
N_2O	kt	0.0000019	0.0000019	0.0000019	0.0000019	0.0000019	0.0000019	0.0000019	0.0000019	0.0000019	0.0000019
Liquid fuels	kt	0.0000019	0.0000019	0.0000019	0.0000019	0.0000019	0.0000019	0.0000019	0.0000019	0.0000019	0.0000019
Amount captured											
CO_2	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liquid fuels	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor											
CO_2											
Liquid fuels	t/TJ	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395
CH_4											
Liquid fuels	kg/TJ	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85
N_2O											
Liquid fuels	kg/TJ	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57

Tokelau CRF Table 1.A.1.a: [1. Energy][1.AA Fuel Combustion – Sectoral approach][1.A.1 Energy Industries][1.A.1.a Public Electricity and Heat Production] (Part 2 of 3)

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.1 Energy Industries][1.A.1.a Public Electricity and Heat Production]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fuel Consumption	TJ	3.268	3.268	3.268	3.268	9.805	16.342	16.342	16.342	16.342	16.342
Liquid fuels	TJ	3.268	3.268	3.268	3.268	9.805	16.342	16.342	16.342	16.342	16.342
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Liquid fuels		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Method											
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CO_2		D	D	D	D	D	D	D	D	D	D

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.1 Energy Industries][1.A.1.a Public Electricity and Heat Production]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CH_4		D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions											
CO_2	kt	0.23	0.23	0.23	0.23	0.69	1.15	1.15	1.15	1.15	1.15
Liquid fuels	kt	0.23	0.23	0.23	0.23	0.69	1.15	1.15	1.15	1.15	1.15
CH_4	kt	0.0000093	0.0000093	0.0000093	0.0000093	0.0000279	0.0000466	0.0000466	0.0000466	0.0000466	0.0000466
Liquid fuels	kt	0.0000093	0.0000093	0.0000093	0.0000093	0.0000279	0.0000466	0.0000466	0.0000466	0.0000466	0.0000466
N_2O	kt	0.0000019	0.0000019	0.0000019	0.0000019	0.0000056	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093
Liquid fuels	kt	0.0000019	0.0000019	0.0000019	0.0000019	0.0000056	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093
Amount captured											
CO_2	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liquid fuels	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor											
CO_2											
Liquid fuels	t/TJ	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395
CH_4											
Liquid fuels	kg/TJ	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85
N_2O											
Liquid fuels	kg/TJ	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57

Tokelau CRF Table 1.A.1.a: [1. Energy][1.AA Fuel Combustion – Sectoral approach][1.A.1 Energy Industries][1.A.1.a Public Electricity and Heat Production] (Part 3 of 3)

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.1 Energy Industries][1.A.1.a Public Electricity and Heat Production]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Fuel Consumption	TJ	16.342	16.342	12.972	2.863	2.863	2.863	3.049	3.235	3.421	3.608	3.206
Liquid fuels	TJ	16.342	16.342	12.972	2.863	2.863	2.863	3.049	3.235	3.421	3.608	3.206
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Liquid fuels		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.1 Energy Industries][1.A.1.a Public Electricity and Heat Production]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Method												
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information												
CO_2		D	D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D	D
Emissions												
CO_2	kt	1.15	1.15	0.913	0.202	0.202	0.202	0.215	0.228	0.241	0.254	0.226
Liquid fuels	kt	1.15	1.15	0.913	0.202	0.202	0.202	0.215	0.228	0.241	0.254	0.226
CH_4	kt	0.0000466	0.0000466	0.000037	0.0000082	0.0000082	0.0000082	0.0000087	0.0000092	0.0000098	0.0000103	0.0000091
Liquid fuels	kt	0.0000466	0.0000466	0.000037	0.0000082	0.0000082	0.0000082	0.0000087	0.0000092	0.0000098	0.0000103	0.0000091
N_2O	kt	0.0000093	0.0000093	0.0000074	0.0000016	0.0000016	0.0000016	0.0000017	0.0000018	0.000002	0.0000021	0.0000018
Liquid fuels	kt	0.0000093	0.0000093	0.0000074	0.0000016	0.0000016	0.0000016	0.0000017	0.0000018	0.000002	0.0000021	0.0000018
Amount captured												
CO_2	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liquid fuels	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor												
CO_2												
Liquid fuels	t/TJ	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395
CH_4												
Liquid fuels	kg/TJ	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85
N_2O												
Liquid fuels	kg/TJ	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57

Tokelau CRF Table 1.A.3.b.i: [1. Energy][1.AA Fuel Combustion – Sectoral approach][1.A.3 Transport][1.A.3.b Road Transportation][1.A.3.b.i Cars][Gasoline] (Part 1 of 3)

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.3 Transport][1.A.3.b Road Transportation][1.A.3.b.i Cars][Gasoline]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Fuel consumption	TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Method											
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CO_2		D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions											
CO_2	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CH_4	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N_2O	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Implied emission factor											
CO_2	t/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4	kg/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
N_2O	kg/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Note: This category is included under 1.A.3.d. For explanation please refer to section 8.2.5.

Tokelau CRF Table 1.A.3.b.i: [1. Energy][1.AA Fuel Combustion – Sectoral approach][1.A.3 Transport][1.A.3.b Road Transportation][1.A.3.b.i Cars][Gasoline] (Part 2 of 3)

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.3 Transport][1.A.3.b Road Transportation][1.A.3.b.i Cars][Gasoline]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fuel consumption	TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Method											

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.3 Transport][1.A.3.b Road Transportation][1.A.3.b.i Cars][Gasoline]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CO_2		D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions											
CO_2	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CH_4	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N_2O	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Implied emission factor											
CO_2	t/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4	kg/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
N_2O	kg/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Tokelau CRF Table 1.A.3.b.i: [1. Energy][1.AA Fuel Combustion – Sectoral approach][1.A.3 Transport][1.A.3.b Road Transportation][1.A.3.b.i Cars][Gasoline] (Part 3 of 3)

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.3 Transport][1.A.3.b Road Transportation][1.A.3.b.i Cars][Gasoline]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Fuel consumption	TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Method												
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information												
CO_2		D	D	D	D	D	D	D	D	D	D	D

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.3 Transport][1.A.3.b Road Transportation][1.A.3.b.i Cars][Gasoline]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CH_4		D	D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D	D
Emissions												
CO_2	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CH_4	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N_2O	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Implied emission factor												
CO_2	t/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4	kg/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
N_2O	kg/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Tokelau CRF Table 1.A.3.b.i Diesel Oil: [1. Energy][1.AA Fuel Combustion – Sectoral approach][1.A.3 Transport][1.A.3.b Road Transportation][1.A.3.b.i Cars][Diesel Oil] (Part 1 of 3)

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.3 Transport][1.A.3.b Road Transportation][1.A.3.b.i Cars][Diesel Oil]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Fuel consumption	TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Calorific value		IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Method											
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CO_2		D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions											
CO_2	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CH_4	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.3 Transport][1.A.3.b Road Transportation][1.A.3.b.i Cars][Diesel Oil]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N_2O	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Implied emission factor											
CO_2	t/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4	kg/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
N_2O	kg/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Tokelau CRF Table 1.A.3.b.i Diesel Oil: [1. Energy][1.AA Fuel Combustion – Sectoral approach][1.A.3 Transport][1.A.3.b Road Transportation][1.A.3.b.i Cars][Diesel Oil] (Part 2 of 3)

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.3 Transport][1.A.3.b Road Transportation][1.A.3.b.i Cars][Diesel Oil]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fuel consumption	TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Calorific value		IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Method											
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CO_2		D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions											
CO_2	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CH_4	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N_2O	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Implied emission factor											
CO_2	t/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4	kg/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
N_2O	kg/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Tokelau CRF Table 1.A.3.b.i Diesel Oil: [1. Energy][1.AA Fuel Combustion – Sectoral approach][1.A.3 Transport][1.A.3.b Road Transportation][1.A.3.b.i Cars][Diesel Oil] (Part 3 of 3)

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.3 Transport][1.A.3.b Road Transportation][1.A.3.b.i Cars][Diesel Oil]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Fuel consumption	TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Calorific value		IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Method												
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information												
CO_2		D	D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D	D
Emissions												
CO_2	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CH_4	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N_2O	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Implied emission factor												
CO_2	t/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4	kg/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
N_2O	kg/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Tokelau CRF Table 1.A.3.d Gas/Diesel Oil: [1. Energy][1.AA Fuel Combustion – Sectoral approach][1.A.3 Transport][1.A.3.d Domestic Navigation][Gas/Diesel Oil] (Part 1 of 3)

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.3 Transport][1.A.3.d Domestic Navigation][Gas/Diesel Oil]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Fuel consumption	TJ	12.757	12.983	13.209	13.434	13.66	13.886	14.111	14.337	14.563	14.788
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Method											
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.3 Transport][1.A.3.d Domestic Navigation][Gas/Diesel Oil]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CO_2		D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions											
CO_2	kt	0.898	0.914	0.93	0.946	0.962	0.977	0.993	1.009	1.025	1.041
CH_4	kt	0.0000848	0.0000863	0.0000878	0.0000893	0.0000908	0.0000923	0.0000938	0.0000953	0.0000968	0.0000983
N_2O	kt	0.0000242	0.0000247	0.0000251	0.0000255	0.000026	0.0000264	0.0000268	0.0000272	0.0000277	0.0000281
Implied emission factor											
CO_2	t/TJ	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395
CH_4	kg/TJ	6.65	6.65	6.65	6.65	6.65	6.65	6.65	6.65	6.65	6.65
N_2O	kg/TJ	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Tokelau CRF Table 1.A.3.d Gas/Diesel Oil: [1. Energy][1.AA Fuel Combustion – Sectoral approach][1.A.3 Transport][1.A.3.d Domestic Navigation][Gas/Diesel Oil] (Part 2 of 3)

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.3 Transport][1.A.3.d Domestic Navigation][Gas/Diesel Oil]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fuel consumption	TJ	15.014	15.24	15.465	15.691	15.917	16.142	16.368	16.594	16.819	17.045
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Method											
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CO_2		D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.3 Transport][1.A.3.d Domestic Navigation][Gas/Diesel Oil]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions											
CO_2	kt	1.057	1.073	1.089	1.105	1.12	1.136	1.152	1.168	1.184	1.2
CH_4	kt	0.0000998	0.0001013	0.0001028	0.0001043	0.0001058	0.0001073	0.0001088	0.0001103	0.0001118	0.0001133
N_2O	kt	0.0000285	0.000029	0.0000294	0.0000298	0.0000302	0.0000307	0.0000311	0.0000315	0.000032	0.0000324
Implied emission factor											
CO_2	t/TJ	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395
CH_4	kg/TJ	6.65	6.65	6.65	6.65	6.65	6.65	6.65	6.65	6.65	6.65
N_2O	kg/TJ	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Tokelau CRF Table 1.A.3.d Gas/Diesel Oil: [1. Energy][1.AA Fuel Combustion – Sectoral approach][1.A.3 Transport][1.A.3.d Domestic Navigation][Gas/Diesel Oil] (Part 3 of 3)

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.3 Transport][1.A.3.d Domestic Navigation][Gas/Diesel Oil]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Fuel consumption	TJ	17.271	17.496	17.722	17.947	18.173	18.031	18.886	19.883	21.079	30.915	29.174
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Method												
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information												
CO_2		D	D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D	D
Emissions												
CO_2	kt	1.216	1.232	1.248	1.263	1.279	1.269	1.329	1.4	1.484	2.176	2.054
CH_4	kt	0.0001148	0.0001163	0.0001179	0.0001194	0.0001209	0.0001199	0.0001256	0.0001322	0.0001402	0.0002056	0.000194
N_2O	kt	0.0000328	0.0000332	0.0000337	0.0000341	0.0000345	0.0000343	0.0000359	0.0000378	0.00004	0.0000587	0.0000554

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.3 Transport][1.A.3.d Domestic Navigation][Gas/Diesel Oil]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Implied emission factor												
CO_2	t/TJ	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395	70.395
CH_4	kg/TJ	6.65	6.65	6.65	6.65	6.65	6.65	6.65	6.65	6.65	6.65	6.65
N_2O	kg/TJ	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9

Tokelau CRF Table 1.A.4.b: [1. Energy][1.AA Fuel Combustion – Sectoral approach][1.A.4 Other Sectors][1.A.4.b Residential] (Part 1 of 3)

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.4 Other Sectors][1.A.4.b Residential]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Fuel Consumption	TJ	2.157	2.157	2.157	2.157	2.157	2.157	2.157	2.157	2.157	2.157
Liquid fuels	TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Gaseous fuels	TJ	2.157	2.157	2.157	2.157	2.157	2.157	2.157	2.157	2.157	2.157
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Liquid fuels		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Gaseous fuels		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Method											
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CO_2		D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions											
CO_2	kt	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123
Liquid fuels	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Gaseous fuels	kt	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123
CH_4	kt	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.4 Other Sectors][1.A.4.b Residential]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Liquid fuels	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Gaseous fuels	kt	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204
N_2O	kt	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004
Liquid fuels	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Gaseous fuels	kt	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004
No_x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
SO_2	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Amount captured											
CO_2	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liquid fuels	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gaseous fuels	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor											
CO_2											
Liquid fuels	t/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gaseous fuels	t/TJ	56.79	56.79	56.79	56.79	56.79	56.79	56.79	56.79	56.79	56.79
CH_4											
Liquid fuels	kg/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gaseous fuels	kg/TJ	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8
N_2O											
Liquid fuels	kg/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gaseous fuels	kg/TJ	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18

Tokelau CRF Table 1.A.4.b: [1. Energy][1.AA Fuel Combustion – Sectoral approach][1.A.4 Other Sectors][1.A.4.b Residential] (Part 2 of 3)

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.4 Other Sectors][1.A.4.b Residential]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fuel Consumption	TJ	2.157	2.157	2.157	2.157	2.157	2.157	2.157	2.157	2.157	2.157
Liquid fuels	TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Gaseous fuels	TJ	2.157	2.157	2.157	2.157	2.157	2.157	2.157	2.157	2.157	2.157
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Liquid fuels		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Gaseous fuels		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Method											
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CO_2		D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions											
CO_2	kt	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123
Liquid fuels	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Gaseous fuels	kt	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123
CH_4	kt	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204
Liquid fuels	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Gaseous fuels	kt	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204
N_2O	kt	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004
Liquid fuels	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Gaseous fuels	kt	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004
No_x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.4 Other Sectors][1.A.4.b Residential]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
NMVOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
SO_2	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Amount captured											
CO_2	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liquid fuels	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gaseous fuels	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor											
CO_2											
Liquid fuels	t/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gaseous fuels	t/TJ	56.79	56.79	56.79	56.79	56.79	56.79	56.79	56.79	56.79	56.79
CH_4											
Liquid fuels	kg/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gaseous fuels	kg/TJ	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8
N_2O											
Liquid fuels	kg/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gaseous fuels	kg/TJ	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18

Tokelau CRF Table 1.A.4.b: [1. Energy][1.AA Fuel Combustion – Sectoral approach][1.A.4 Other Sectors][1.A.4.b Residential] (Part 3 of 3)

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.4 Other Sectors][1.A.4.b Residential]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Fuel Consumption	TJ	2.157	2.157	2.157	2.157	2.157	2.157	2.157	2.157	2.157	1.252	1.763
Liquid fuels	TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Gaseous fuels	TJ	2.157	2.157	2.157	2.157	2.157	2.157	2.157	2.157	2.157	1.252	1.763
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Liquid fuels		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Gaseous fuels		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Method												
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.4 Other Sectors][1.A.4.b Residential]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information												
CO_2		D	D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D	D
Emissions												
CO_2	kt	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.071	0.1
Liquid fuels	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Gaseous fuels	kt	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.071	0.1
CH_4	kt	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0000698	0.0000983
Liquid fuels	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Gaseous fuels	kt	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0000698	0.0000983
N_2O	kt	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000002	0.0000003
Liquid fuels	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Gaseous fuels	kt	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000002	0.0000003
No_x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
SO_2	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Amount captured												
CO_2	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liquid fuels	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gaseous fuels	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor												
CO_2												
Liquid fuels	t/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gaseous fuels	t/TJ	56.79	56.79	56.79	56.79	56.79	56.79	56.79	56.79	56.79	56.79	56.79
CH_4												

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.4 Other Sectors][1.A.4.b Residential]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Liquid fuels	kg/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gaseous fuels	kg/TJ	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8
N_2O												
Liquid fuels	kg/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gaseous fuels	kg/TJ	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18

Tokelau CRF Table 1.A.4.c.iii Gas/Diesel Oil: [1. Energy][1.AA Fuel Combustion – Sectoral approach][1.A.4 Other Sectors][1.A.4.c Agriculture/Forestry/Fishing][1.A.4.c.iii Fishing][Gas/Diesel Oil] (Part 1 of 3)

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.4 Other Sectors][1.A.4.c Agriculture/Forestry/Fishing][1.A.4.c.iii Fishing][Gas/Diesel Oil]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Fuel consumption	TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Method											
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CO_2		D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions											
CO_2	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CH_4	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N_2O	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Implied emission factor											
CO_2	t/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4	kg/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
N_2O	kg/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Tokelau CRF Table 1.A.4.c.iii Gas/Diesel Oil: [1. Energy][1.AA Fuel Combustion – Sectoral approach][1.A.4 Other Sectors][1.A.4.c Agriculture/Forestry/Fishing][1.A.4.c.iii Fishing][Gas/Diesel Oil] (Part 2 of 3)

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.4 Other Sectors][1.A.4.c Agriculture/Forestry/Fishing][1.A.4.c.iii Fishing][Gas/Diesel Oil]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fuel consumption	2	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Method											
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CO_2		D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions											
CO_2	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CH_4	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N_2O	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Implied emission factor											
CO_2	t/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4	kg/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
N_2O	kg/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Tokelau CRF Table 1.A.4.c.iii Gas/Diesel Oil: [1. Energy][1.AA Fuel Combustion – Sectoral approach][1.A.4 Other Sectors][1.A.4.c Agriculture/Forestry/Fishing][1.A.4.c.iii Fishing][Gas/Diesel Oil] (Part 3 of 3)

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.4 Other Sectors][1.A.4.c Agriculture/Forestry/Fishing][1.A.4.c.iii Fishing][Gas/Diesel Oil]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Fuel consumption	TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Method												

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.4 Other Sectors][1.A.4.c Agriculture/Forestry/Fishing][1.A.4.c.iii Fishing][Gas/Diesel Oil]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information												
CO_2		D	D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D	D
Emissions												
CO_2	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CH_4	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N_2O	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Implied emission factor												
CO_2	t/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4	kg/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
N_2O	kg/TJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Tokelau CRF Table 1.AB Gasoline: [1. Energy][1.AB Fuel Combustion – Reference Approach][Liquid Fuels][Gasoline] (Part 1 of 3)

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Gasoline]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Imports	PJ	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Exports	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	PJ	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Conversion factor	TJ/unit	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Apparent consumption	TJ	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802
Emission factor											

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Gasoline]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
C	t/TJ	17.955	17.955	17.955	17.955	17.955	17.955	17.955	17.955	17.955	17.955
Carbon content											
C	kt	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176
Carbon stored											
C	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Net carbon emissions											
C	kt	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1
Emissions											
C	kt	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176
CO_2	kt	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645

Tokelau CRF Table 1.AB Gasoline: [1. Energy][1.AB Fuel Combustion – Reference Approach][Liquid Fuels][Gasoline] (Part 2 of 3)

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Gasoline]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Imports	PJ	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Exports	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	PJ	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Conversion factor	TJ/unit	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Apparent consumption	TJ	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802
Emission factor											
C	t/TJ	17.955	17.955	17.955	17.955	17.955	17.955	17.955	17.955	17.955	17.955
Carbon content											
C	kt	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176
Carbon stored											
C	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Gasoline]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Net carbon emissions											
C	kt	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1
Emissions											
C	kt	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176
CO_2	kt	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645

Tokelau CRF Table 1.AB Gasoline: [1. Energy][1.AB Fuel Combustion – Reference Approach][Liquid Fuels][Gasoline] (Part 3 of 3)

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Gasoline]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Imports	PJ	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.009	0.011
Exports	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	PJ	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.009	0.011
Conversion factor	TJ/unit	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Apparent consumption	TJ	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.387	11.262
Emission factor												
C	t/TJ	17.955	17.955	17.955	17.955	17.955	17.955	17.955	17.955	17.955	17.955	17.955
Carbon content												
C	kt	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.169	0.202
Carbon stored												
C	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Net carbon emissions												
C	kt	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.169	0.202
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1	1
Emissions												
C	kt	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.169	0.202
CO_2	kt	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.618	0.741

Tokelau CRF Table 1.AB Gas Diesel Oil: [1. Energy][1.AB Fuel Combustion – Reference Approach][Liquid Fuels][Gas / Diesel Oil] (Part 1 of 3)

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Gas / Diesel Oil]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Imports	PJ	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.008	0.008
Exports	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	PJ	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.008	0.008
Conversion factor	TJ/unit	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Apparent consumption	TJ	5.834	6.059	6.285	6.511	6.736	6.962	7.188	7.413	7.639	7.865
Emission factor											
C	t/TJ	19.19	19.19	19.19	19.19	19.19	19.19	19.19	19.19	19.19	19.19
Carbon content											
C	kt	0.112	0.116	0.121	0.125	0.129	0.134	0.138	0.142	0.147	0.151
Carbon stored											
C	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Net carbon emissions											
C	kt	0.112	0.116	0.121	0.125	0.129	0.134	0.138	0.142	0.147	0.151
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1
Emissions											
C	kt	0.112	0.116	0.121	0.125	0.129	0.134	0.138	0.142	0.147	0.151
CO_2	kt	0.41	0.426	0.442	0.458	0.474	0.49	0.506	0.522	0.538	0.553

Tokelau CRF Table 1.AB Gas Diesel Oil: [1. Energy][1.AB Fuel Combustion – Reference Approach][Liquid Fuels][Gas / Diesel Oil] (Part 2 of 3)

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Gas / Diesel Oil]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Imports	PJ	0.008	0.008	0.009	0.009	0.016	0.022	0.023	0.023	0.023	0.023
Exports	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Gas / Diesel Oil]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Stock change	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	PJ	0.008	0.008	0.009	0.009	0.016	0.022	0.023	0.023	0.023	0.023
Conversion factor	TJ/unit	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Apparent consumption	TJ	8.09	8.316	8.542	8.767	15.53	22.292	22.518	22.743	22.969	23.195
Emission factor											
C	t/TJ	19.19	19.19	19.19	19.19	19.19	19.19	19.19	19.19	19.19	19.19
Carbon content											
C	kt	0.155	0.16	0.164	0.168	0.298	0.428	0.432	0.436	0.441	0.445
Carbon stored											
C	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Net carbon emissions											
C	kt	0.155	0.16	0.164	0.168	0.298	0.428	0.432	0.436	0.441	0.445
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1
Emissions											
C	kt	0.155	0.16	0.164	0.168	0.298	0.428	0.432	0.436	0.441	0.445
CO_2	kt	0.569	0.585	0.601	0.617	1.093	1.569	1.584	1.6	1.616	1.632

Tokelau CRF Table 1.AB Gas Diesel Oil: [1. Energy][1.AB Fuel Combustion – Reference Approach][Liquid Fuels][Gas / Diesel Oil] (Part 3 of 3)

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Gas / Diesel Oil]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Imports	PJ	0.023	0.024	0.021	0.011	0.011	0.011	0.012	0.013	0.014	0.025	0.021
Exports	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	PJ	0.023	0.024	0.021	0.011	0.011	0.011	0.012	0.013	0.014	0.025	0.021
Conversion factor	TJ/unit	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Apparent consumption	TJ	23.42	23.646	20.502	10.618	10.844	10.701	11.743	12.927	14.308	24.984	20.916

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Gas / Diesel Oil]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Emission factor												
C	t/TJ	19.19	19.19	19.19	19.19	19.19	19.19	19.19	19.19	19.19	19.19	19.19
Carbon content												
C	kt	0.449	0.454	0.393	0.204	0.208	0.205	0.225	0.248	0.275	0.479	0.401
Carbon stored												
C	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Net carbon emissions												
C	kt	0.449	0.454	0.393	0.204	0.208	0.205	0.225	0.248	0.275	0.479	0.401
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1	1
Emissions												
C	kt	0.449	0.454	0.393	0.204	0.208	0.205	0.225	0.248	0.275	0.479	0.401
CO_2	kt	1.648	1.664	1.443	0.747	0.763	0.753	0.826	0.91	1.007	1.758	1.472

Tokelau CRF Table 1.AB Other Kerosene: [1. Energy][1.AB Fuel Combustion – Reference Approach][Liquid Fuels][Other Kerosene] (Part 1 of 3)

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Other Kerosene]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Imports	PJ	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661
Exports	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	PJ	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661
Conversion factor	TJ/unit	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Apparent consumption	TJ	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666
Emission factor											
C	t/TJ	18.62	18.62	18.62	18.62	18.62	18.62	18.62	18.62	18.62	18.62
Carbon content											
C	kt	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Other Kerosene]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Carbon stored											
C	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Net carbon emissions											
C	kt	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1
Emissions											
C	kt	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
CO_2	kt	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045

Tokelau CRF Table 1.AB Other Kerosene: [1. Energy][1.AB Fuel Combustion – Reference Approach][Liquid Fuels][Other Kerosene] (Part 2 of 3)

[1. Energy][1.AB Fuel Combustion - Reference Approach] [Liquid Fuels][Other Kerosene]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Imports	PJ	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661
Exports	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	PJ	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661
Conversion factor	TJ/unit	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Apparent consumption	TJ	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666
Emission factor											
C	t/TJ	18.62	18.62	18.62	18.62	18.62	18.62	18.62	18.62	18.62	18.62
Carbon content											
C	kt	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
Carbon stored											
C	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Net carbon emissions											
C	kt	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012

[1. Energy][1.AB Fuel Combustion - Reference Approach] [Liquid Fuels][Other Kerosene]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1
Emissions											
C	kt	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
CO_2	kt	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045

Tokelau CRF Table 1.AB Other Kerosene: [1. Energy][1.AB Fuel Combustion – Reference Approach][Liquid Fuels][Other Kerosene] (Part 3 of 3)

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Other Kerosene]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Imports	PJ	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0002342	0.0000952
Exports	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	PJ	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0002342	0.0000952
Conversion factor	TJ/unit	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Apparent consumption	TJ	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.234	0.095
Emission factor												
C	t/TJ	18.62	18.62	18.62	18.62	18.62	18.62	18.62	18.62	18.62	18.62	18.62
Carbon content												
C	kt	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.004	0.002
Carbon stored												
C	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Net carbon emissions												
C	kt	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.004	0.002
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1	1
Emissions												
C	kt	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.004	0.002
CO_2	kt	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.016	0.006

Tokelau CRF Table 1.AB LPG: [1. Energy][1.AB Fuel Combustion – Reference Approach][Liquid Fuels][Liquefied Petroleum Gases (LPG)] (Part 1 of 3)

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Liquefied Petroleum Gases (LPG)]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Imports	PJ	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Exports	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	PJ	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Conversion factor	TJ/unit	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Apparent consumption	TJ	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491
Emission factor											
C	t/TJ	15.48	15.48	15.48	15.48	15.48	15.48	15.48	15.48	15.48	15.48
Carbon content											
C	kt	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
Carbon stored											
C	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Net carbon emissions											
C	kt	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1
Emissions											
C	kt	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
CO_2	kt	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085

Tokelau CRF Table 1.AB LPG: [1. Energy][1.AB Fuel Combustion – Reference Approach][Liquid Fuels][Liquefied Petroleum Gases (LPG)] (Part 2 of 3)

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Liquefied Petroleum Gases (LPG)]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Imports	PJ	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Exports	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Liquefied Petroleum Gases (LPG)]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Stock change	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	PJ	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Conversion factor	TJ/unit	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Apparent consumption	TJ	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491
Emission factor											
C	t/TJ	15.48	15.48	15.48	15.48	15.48	15.48	15.48	15.48	15.48	15.48
Carbon content											
C	kt	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
Carbon stored											
C	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Net carbon emissions											
C	kt	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1
Emissions											
C	kt	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
CO_2	kt	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085

Tokelau CRF Table 1.AB LPG: [1. Energy][1.AB Fuel Combustion – Reference Approach][Liquid Fuels][Liquefied Petroleum Gases (LPG)] (Part 3 of 3)

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Liquefied Petroleum Gases (LPG)]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Imports	PJ	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002
Exports	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	PJ	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002
Conversion factor	TJ/unit	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Liquefied Petroleum Gases (LPG)]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Apparent consumption	TJ	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.017	1.667
Emission factor												
C	t/TJ	15.48	15.48	15.48	15.48	15.48	15.48	15.48	15.48	15.48	15.48	15.48
Carbon content												
C	kt	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.016	0.026
Carbon stored												
C	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Net carbon emissions												
C	kt	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.016	0.026
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1	1
Emissions												
C	kt	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.016	0.026
CO_2	kt	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.058	0.095

Tokelau CRF Table 1.AB Lubricants: [1. Energy][1.AB Fuel Combustion – Reference Approach][Liquid Fuels][Lubricants] (Part 1 of 3)

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Lubricants]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Imports	PJ	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901
Exports	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	PJ	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901
Conversion factor	TJ/unit	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Apparent consumption	TJ	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
Emission factor											
C	t/TJ	19	19	19	19	19	19	19	19	19	19
Carbon content											
C	kt	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Lubricants]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Carbon stored											
C	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Net carbon emissions											
C	kt	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1
Emissions											
C	kt	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
CO_2	kt	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029

Tokelau CRF Table 1.AB Lubricants: [1. Energy][1.AB Fuel Combustion – Reference Approach][Liquid Fuels][Lubricants] (Part 2 of 3)

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Lubricants]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Imports	PJ	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901
Exports	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	PJ	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901
Conversion factor	TJ/unit	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Apparent consumption	TJ	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
Emission factor											
C	t/TJ	19	19	19	19	19	19	19	19	19	19
Carbon content											
C	kt	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
Carbon stored											
C	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Net carbon emissions											
C	kt	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Lubricants]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1
Emissions											
C	kt	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
CO_2	kt	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029

Tokelau CRF Table 1.AB Lubricants: [1. Energy][1.AB Fuel Combustion – Reference Approach][Liquid Fuels][Lubricants] (Part 3 of 3)

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Lubricants]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Imports	PJ	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0001519	0.0002028
Exports	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	PJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	PJ	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0001519	0.0002028
Conversion factor	TJ/unit	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Apparent consumption	TJ	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.152	0.203
Emission factor												
C	t/TJ	19	19	19	19	19	19	19	19	19	19	19
Carbon content												
C	kt	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.003	0.004
Carbon stored												
C	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Net carbon emissions												
C	kt	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.003	0.004
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1	1
Emissions												
C	kt	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.003	0.004
CO_2	kt	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.011	0.015

Tokelau CRF Table 2.F.1.b HFC-134a Product Uses as Substitutes for ODS: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.b Domestic Refrigeration][HFC-134a] (Part 1 of 3)

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.b Domestic Refrigeration][HFC-134a]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Amount											
Filled into new manufactured products	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
In operating systems (average annual stocks)	t	NO	NO	NO	NO	0.016	0.039	0.067	0.088	0.107	0.126
Remaining in products at decommissioning	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	NO	NO	NO	NO	0.002	0.006	0.01	0.013	0.016	0.019
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	NO	NO	NO	NO	0.002	0.006	0.01	0.013	0.016	0.019
From disposal	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Recovery	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor											
Product manufacturing factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Product life factor	%	NO	NO	NO	NO	15	15	15	15	15	15
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau CRF Table 2.F.1.b HFC-134a Product Uses as Substitutes for ODS: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.b Domestic Refrigeration][HFC-134a] (Part 2 of 3)

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.b Domestic Refrigeration][HFC-134a]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Amount											
Filled into new manufactured products	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
In operating systems (average annual stocks)	t	0.143	0.16	0.201	0.247	0.271	0.295	0.318	0.316	0.313	0.311
Remaining in products at decommissioning	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	0.022	0.024	0.03	0.037	0.041	0.044	0.048	0.047	0.047	0.047
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	0.022	0.024	0.03	0.037	0.041	0.044	0.048	0.047	0.047	0.047
From disposal	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.b Domestic Refrigeration][HFC-134a]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Recovery	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor											
Product manufacturing factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Product life factor	%	15	15	15	15	15	15	15	15	15	15
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau CRF Table 2.F.1.b HFC-134a Product Uses as Substitutes for ODS: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.b Domestic Refrigeration][HFC-134a] (Part 3 of 3)

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.b Domestic Refrigeration][HFC-134a]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Amount												
Filled into new manufactured products	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
In operating systems (average annual stocks)	t	0.308	0.306	0.286	0.267	0.247	0.228	0.208	0.208	0.208	0.208	0.208
Remaining in products at decommissioning	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	0.046	0.046	0.043	0.04	0.037	0.034	0.031	0.031	0.031	0.031	0.031
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	0.046	0.046	0.043	0.04	0.037	0.034	0.031	0.031	0.031	0.031	0.031
From disposal	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Recovery	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor												
Product manufacturing factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Product life factor	%	15	15	15	15	15	15	15	15	15	15	15
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau CRF Table 2.F.1.f: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning] [2.F.1.f Stationary Air Conditioning] (Part 1 of 3)

[2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air-Conditioning]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Method											
HFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of HFCs and PFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SF_6		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NF_3		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emission factor information											
HFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emissions											
HFCs	t CO_2-e	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-32	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-125	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-134a	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFCs and PFCs	t CO_2-e	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Recovery											
Aggregate F-gases	t CO_2-e	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau CRF Table 2.F.1.f: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air Conditioning] (Part 2 of 3)

[2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air-Conditioning]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Method											
HFCs		NA	NA	NA	NA	NA	NA	NA	T1a	T1a	T1a
PFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of HFCs and PFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SF_6		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

[2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air-Conditioning]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
NF_3		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emission factor information											
HFCs		NA	NA	NA	NA	NA	NA	NA	D	D	D
Emissions											
HFCs	t CO_2-e	NO	NO	NO	NO	NO	NO	NO	17.058	34.116	51.174
HFC-32	t	NO	NO	NO	NO	NO	NO	NO	0.003	0.006	0.009
HFC-125	t	NO	NO	NO	NO	NO	NO	NO	0.004	0.008	0.013
HFC-134a	t	NO	NO	NO	NO	NO	NO	NO	0.000285	0.00057	0.000855
HFCs and PFCs	t CO_2-e	NO	NO	NO	NO	NO	NO	NO	17.058	34.116	51.174
Recovery											
Aggregate F-gases	t CO_2-e	NO	NO	NO	NO	NO	NO	NO	17.058	34.116	51.174

Tokelau CRF Table 2.F.1.f: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air Conditioning] (Part 3 of 3)

[2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air-Conditioning]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Method												
HFCs		T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a
PFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of HFCs and PFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SF_6		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NF_3		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emission factor information												
HFCs		D	D	D	D	D	D	D	D	D	D	D
Emissions												
HFCs	t CO_2-e	68.232	85.29	102.348	119.405	136.463	153.521	170.579	170.579	170.579	170.579	170.579
HFC-32	t	0.012	0.015	0.018	0.021	0.024	0.027	0.03	0.03	0.03	0.03	0.03
HFC-125	t	0.017	0.021	0.025	0.029	0.033	0.038	0.042	0.042	0.042	0.042	0.042

[2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air-Conditioning]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
HFC-134a	t	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003
HFCs and PFCs	t CO_2-e	68.232	85.29	102.348	119.405	136.463	153.521	170.579	170.579	170.579	170.579	170.579
Recovery												
Aggregate F-gases	t CO_2-e	68.232	85.29	102.348	119.405	136.463	153.521	170.579	170.579	170.579	170.579	170.579

Tokelau CRF Table 2.F.1.f HFC-32: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air conditioning][HFC-32] (Part 1 of 3)

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air-Conditioning][HFC-32]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Amount											
Filled into new manufactured products	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
In operating systems (average annual stocks)	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Remaining in products at decommissioning	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From disposal	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Recovery	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor											
Product manufacturing factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Product life factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau CRF Table 2.F.1.f HFC-32: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air conditioning][HFC-32] (Part 2 of 3)

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air-Conditioning][HFC-32]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Amount											
Filled into new manufactured products	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
In operating systems (average annual stocks)	t	NO	NO	NO	NO	NO	NO	NO	0.02	0.041	0.061
Remaining in products at decommissioning	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	NO	NO	NO	NO	NO	NO	NO	0.003	0.006	0.009
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	NO	NO	NO	NO	NO	NO	NO	0.003	0.006	0.009
From disposal	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Recovery	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor											
Product manufacturing factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Product life factor	%	NO	NO	NO	NO	NO	NO	NO	15	15	15
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau CRF Table 2.F.1.f HFC-32: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air conditioning][HFC-32] (Part 3 of 3)

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air-Conditioning][HFC-32]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Amount												
Filled into new manufactured products	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
In operating systems (average annual stocks)	t	0.081	0.102	0.122	0.142	0.162	0.183	0.203	0.203	0.203	0.203	0.203
Remaining in products at decommissioning	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	0.012	0.015	0.018	0.021	0.024	0.027	0.03	0.03	0.03	0.03	0.03
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	0.012	0.015	0.018	0.021	0.024	0.027	0.03	0.03	0.03	0.03	0.03
From disposal	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air-Conditioning][HFC-32]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Recovery	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor												
Product manufacturing factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Product life factor	%	15	15	15	15	15	15	15	15	15	15	15
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau CRF Table 2.F.1.f HFC-125: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air conditioning][HFC-125] (Part 1 of 3)

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air-Conditioning][HFC-125]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Amount											
Filled into new manufactured products	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
In operating systems (average annual stocks)	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Remaining in products at decommissioning	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From disposal	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Recovery	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor											
Product manufacturing factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Product life factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau CRF Table 2.F.1.f HFC-125: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air conditioning][HFC-125] (Part 2 of 3)

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air-Conditioning][HFC-125]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Amount											
Filled into new manufactured products	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
In operating systems (average annual stocks)	t	NO	NO	NO	NO	NO	NO	NO	0.028	0.056	0.083
Remaining in products at decommissioning	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	NO	NO	NO	NO	NO	NO	NO	0.004	0.008	0.013
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	NO	NO	NO	NO	NO	NO	NO	0.004	0.008	0.013
From disposal	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Recovery	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor											
Product manufacturing factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Product life factor	%	NO	NO	NO	NO	NO	NO	NO	15	15	15
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau CRF Table 2.F.1.f HFC-125: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air conditioning][HFC-125] (Part 3 of 3)

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air-Conditioning][HFC-125]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Amount												
Filled into new manufactured products	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
In operating systems (average annual stocks)	t	0.111	0.139	0.167	0.195	0.222	0.25	0.278	0.278	0.278	0.278	0.278
Remaining in products at decommissioning	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	0.017	0.021	0.025	0.029	0.033	0.038	0.042	0.042	0.042	0.042	0.042
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	0.017	0.021	0.025	0.029	0.033	0.038	0.042	0.042	0.042	0.042	0.042
From disposal	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Recovery	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air-Conditioning][HFC-125]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Implied emission factor												
Product manufacturing factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Product life factor	%	15	15	15	15	15	15	15	15	15	15	15
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau CRF Table 2.F.1.f HFC-134a: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air conditioning][HFC-134a] (Part 1 of 3)

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air-Conditioning][HFC-134a]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Amount											
Filled into new manufactured products	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
In operating systems (average annual stocks)	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Remaining in products at decommissioning	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From disposal	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Recovery	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor											
Product manufacturing factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Product life factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau CRF Table 2.F.1.f HFC-134a: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air conditioning][HFC-134a] (Part 2 of 3)

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air-Conditioning][HFC-134a]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Amount											
Filled into new manufactured products	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
In operating systems (average annual stocks)	t	NO	NO	NO	NO	NO	NO	NO	0.002	0.004	0.006
Remaining in products at decommissioning	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	NO	NO	NO	NO	NO	NO	NO	0.000285	0.00057	0.000855
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	NO	NO	NO	NO	NO	NO	NO	0.000285	0.00057	0.000855
From disposal	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Recovery	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor											
Product manufacturing factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Product life factor	%	NO	NO	NO	NO	NO	NO	NO	15	15	15
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau CRF Table 2.F.1.f HFC-134a: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air conditioning][HFC-134a] (Part 3 of 3)

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air-Conditioning][HFC-134a]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Amount												
Filled into new manufactured products	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
In operating systems (average annual stocks)	t	0.008	0.01	0.011	0.013	0.015	0.017	0.019	0.019	0.019	0.019	0.019
Remaining in products at decommissioning	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003
From disposal	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.1 Refrigeration and Air conditioning][2.F.1.f Stationary Air-Conditioning][HFC-134a]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Recovery	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor												
Product manufacturing factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Product life factor	%	15	15	15	15	15	15	15	15	15	15	15
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau CRF Table 2.F.4.a: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers] (Part 1 of 3)

[2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Method											
HFCs		NA	NA	NA	NA	NA	T1a	T1a	T1a	T1a	T1a
PFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of HFCs and PFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SF_6		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NF_3		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emission factor information											
HFCs		NA	NA	NA	NA	NA	D	D	D	D	D
PFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of HFCs and PFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SF_6		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NF_3		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emissions	kt CO_2-equivalent	NO	NO	NO	NO	NO	0.0001188	0.0006994	0.001	0.002	0.002
HFCs	t CO_2-equivalent	NO	NO	NO	NO	NO	0.119	0.699	1.144	1.691	2.44
HFC-134a	t	NO	NO	NO	NO	NO	0.0000831	0.0004891	0.0008003	0.001	0.002
HFC-227ea	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Aggregate F-gases	t CO_2-equivalent	NO	NO	NO	NO	NO	0.119	0.699	1.144	1.691	2.44

Tokelau CRF Table 2.F.4.a: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers] (Part 2 of 3)

[2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Method											
HFCs		T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a
PFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of HFCs and PFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SF_6		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NF_3		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emission factor information											
HFCs		D	D	D	D	D	D	D	D	D	D
PFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of HFCs and PFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SF_6		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NF_3		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emissions	kt CO_2-equivalent	0.003	0.006	0.012	0.014	0.014	0.014	0.013	0.014	0.014	0.015
HFCs	t CO_2-equivalent	2.854	6.092	11.539	13.899	13.655	13.66	13.35	13.618	14.176	14.762
HFC-134a	t	0.002	0.004	0.008	0.01	0.01	0.01	0.009	0.01	0.01	0.01
HFC-227ea	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Aggregate F-gases	t CO_2-equivalent	2.854	6.092	11.539	13.899	13.655	13.66	13.35	13.618	14.176	14.762

Tokelau CRF Table 2.F.4.a: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers] (Part 3 of 3)

[2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Method												
HFCs		T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a
PFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of HFCs and PFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SF_6		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

[2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NF_3		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emission factor information												
HFCs		D	D	D	D	D	D	D	D	D	D	D
PFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of HFCs and PFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SF_6		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NF_3		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emissions	kt CO_2-equivalent	0.015	0.017	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.018	0.018
HFCs	t CO_2-equivalent	15.458	17.215	18.929	19.094	19.1	19.399	19.418	19.088	18.636	18.274	18.274
HFC-134a	t	0.011	0.011	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
HFC-227ea	t	NO	0.0003553	0.0007195	0.0007207	0.0007209	0.0007322	0.0007135	0.0006659	0.000614	0.0005628	0.0005628
Aggregate F-gases	t CO_2-equivalent	15.458	17.215	18.929	19.094	19.1	19.399	19.418	19.088	18.636	18.274	18.274

Tokelau CRF Table 2.F.4.a HFC-134a: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers][HFC-134a] (Part 1 of 3)

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers][HFC-134a]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Amount											
Filled into new manufactured products	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
In operating systems (average annual stocks)	t	NO	NO	NO	NO	NO	0.0000831	0.0004891	0.0008003	0.001	0.002
Emissions	t	NO	NO	NO	NO	NO	0.0000831	0.0004891	0.0008003	0.001	0.002
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	NO	NO	NO	NO	NO	0.0000831	0.0004891	0.0008003	0.001	0.002
Recovery	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor											
Product manufacturing factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Product life factor	%	NO	NO	NO	NO	NO	100	100	100	100	100

Tokelau CRF Table 2.F.4.a HFC-134a: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers][HFC-134a] (Part 2 of 3)

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers][HFC-134a]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Amount											
Filled into new manufactured products	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
In operating systems (average annual stocks)	t	0.002	0.004	0.008	0.01	0.01	0.01	0.009	0.01	0.01	0.01
Emissions	t	0.002	0.004	0.008	0.01	0.01	0.01	0.009	0.01	0.01	0.01
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	0.002	0.004	0.008	0.01	0.01	0.01	0.009	0.01	0.01	0.01
Recovery	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor											
Product manufacturing factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Product life factor	%	100	100	100	100	100	100	100	100	100	100

Tokelau CRF Table 2.F.4.a HFC-134a: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers][HFC-134a] (Part 3 of 3)

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers][HFC-134a]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Amount												
Filled into new manufactured products	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
In operating systems (average annual stocks)	t	0.011	0.011	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
Emissions	t	0.011	0.011	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	0.011	0.011	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
Recovery	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor												
Product manufacturing factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Product life factor	%	100	100	100	100	100	100	100	100	100	100	100

Tokelau CRF Table 2.F.4.a HFC-227ea: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers][HFC-227ea] (Part 1 of 3)

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers][HFC-227ea]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Amount											
Filled into new manufactured products	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
In operating systems (average annual stocks)	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Recovery	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor											
Product manufacturing factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Product life factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau CRF Table 2.F.4.a HFC-227ea: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers][HFC-227ea] (Part 2 of 3)

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers][HFC-227ea]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Amount											
Filled into new manufactured products	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
In operating systems (average annual stocks)	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Recovery	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor											
Product manufacturing factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Product life factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau CRF Table 2.F.4.a HFC-227ea: [2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers][HFC-227ea] (Part 3 of 3)

[Sectors/Totals][2. Industrial Processes and Product Use][2.F Product Uses as Substitutes for ODS][2.F.4 Aerosols][2.F.4.a Metered Dose Inhalers][HFC-227ea]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Amount												
Filled into new manufactured products	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
In operating systems (average annual stocks)	t	NO	0.0003553	0.0007195	0.0007207	0.0007209	0.0007322	0.0007135	0.0006659	0.000614	0.0005628	0.0005628
Emissions	t	NO	0.0003553	0.0007195	0.0007207	0.0007209	0.0007322	0.0007135	0.0006659	0.000614	0.0005628	0.0005628
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	NO	0.0003553	0.0007195	0.0007207	0.0007209	0.0007322	0.0007135	0.0006659	0.000614	0.0005628	0.0005628
Recovery	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor												
Product manufacturing factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Product life factor	%	NO	100	100	100	100	100	100	100	100	100	100

Tokelau CRF Table 2.G.3.a: [2. Industrial Processes and Product Use][2.G Other Product Manufacture and Use][2.G.3 N2O from Product Uses][2.G.3.a Medical Applications] (Part 1 of 3)

[2. Industrial Processes and Product Use][2.G Other Product Manufacture and Use][2.G.3 N2O from Product Uses][2.G.3.a Medical Applications]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Activity data											
N_2O	kt	0.000154	0.0001391	0.0001303	0.0001217	0.0001136	0.0001058	0.0000986	0.000092	0.0000861	0.0000807
Method											
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions											
N_2O	kt	0.000158	0.0001428	0.0001337	0.0001249	0.0001166	0.0001086	0.0001012	0.0000944	0.0000884	0.0000828
Recovery											
N_2O	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor											
N_2O	t/t	1.026	1.026	1.026	1.026	1.026	1.026	1.026	1.026	1.026	1.026

Tokelau CRF Table 2.G.3.a: [2. Industrial Processes and Product Use][2.G Other Product Manufacture and Use][2.G.3 N2O from Product Uses][2.G.3.a Medical Applications] (Part 2 of 3)

[2. Industrial Processes and Product Use][2.G Other Product Manufacture and Use][2.G.3 N2O from Product Uses][2.G.3.a Medical Applications]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Activity data											
N_2O	kt	0.0000756	0.0000705	0.000063	0.0000553	0.0000482	0.0000416	0.0000355	0.0000454	0.0000515	0.0000462
Method											
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions											
N_2O	kt	0.0000776	0.0000724	0.0000647	0.0000573	0.0000502	0.0000435	0.0000373	0.0000405	0.0000485	0.0000488
Recovery											
N_2O	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor											
N_2O	t/t	1.026	1.026	1.026	1.036	1.042	1.045	1.05	0.892	0.941	1.056

Tokelau CRF Table 2.G.3.a: [2. Industrial Processes and Product Use][2.G Other Product Manufacture and Use][2.G.3 N2O from Product Uses][2.G.3.a Medical Applications] (Part 3 of 3)

[2. Industrial Processes and Product Use][2.G Other Product Manufacture and Use][2.G.3 N2O from Product Uses][2.G.3.a Medical Applications]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Activity data												
N_2O	kt	0.0000519	0.000046	0.0000566	0.0000542	0.0000538	0.0000564	0.0000508	0.0000598	0.0000837	0.000063	0.000063
Method												
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information												
N_2O		D	D	D	D	D	D	D	D	D	D	D
Emissions												
N_2O	kt	0.000049	0.000049	0.0000515	0.0000554	0.0000538	0.0000549	0.0000534	0.0000548	0.0000713	0.0000729	0.0000729
Recovery												

[2. Industrial Processes and Product Use][2.G Other Product Manufacture and Use][2.G.3 N2O from Product Uses][2.G.3.a Medical Applications]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
N_2O	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor												
N_2O	t/t	0.945	1.065	0.91	1.023	1	0.973	1.05	0.917	0.851	1.157	1.157

Tokelau CRF Table 3.A.3 Tokelau Swine: [3. Agriculture][3.1 Livestock][3.A Enteric Fermentation][3.A.3 Swine][Other (please specify)][Tokelau_Swine] (Part 1 of 3)

[Sectors/Totals][3. Agriculture][3.1 Livestock][3.A Enteric Fermentation][3.A.3 Swine][Other (please specify)][Pigs]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Population	1000s	2.293	2.5	2.395	2.29	2.186	2.081	1.976	2.111	2.247	2.382
Average gross energy intake	MJ/head/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Average CH_4 conversion rate	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Method											
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CH_4		D	D	D	D	D	D	D	D	D	D
Emissions											
CH_4	kt	0.003	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.004
Implied emission factor											
CH_4	kg/head/year	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Additional information											
Weight	kg	80	80	80	80	80	80	80	80	80	80
Feeding situation		Pen	Pen	Pen	Pen	Pen	Pen	Pen	Pen	Pen	Pen
Milk yield	kg/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Work	h/day	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Pregnant	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Digestibility of feed	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gross energy	MJ/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Tokelau CRF Table 3.A.3 Tokelau Swine: [3. Agriculture][3.1 Livestock][3.A Enteric Fermentation][3.A.3 Swine][Other (please specify)][Tokelau_Swine] (Part 2 of 3)

[Sectors/Totals][3. Agriculture][3.1 Livestock][3.A Enteric Fermentation][3.A.3 Swine][Other (please specify)][Pigs]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Population	1000s	2.518	2.653	2.633	2.613	2.592	2.572	2.552	2.514	2.476	2.438
Average gross energy intake	MJ/head/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Average CH_4 conversion rate	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Method											
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CH_4		D	D	D	D	D	D	D	D	D	D
Emissions											
CH_4	kt	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Implied emission factor											
CH_4	kg/head/year	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Additional information											
Weight	kg	80	80	80	80	80	80	80	80	80	80
Feeding situation		Pen	Pen	Pen	Pen	Pen	Pen	Pen	Pen	Pen	Pen
Milk yield	kg/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Work	h/day	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Pregnant	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Digestibility of feed	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gross energy	MJ/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Tokelau CRF Table 3.A.3 Tokelau Swine: [3. Agriculture][3.1 Livestock][3.A Enteric Fermentation][3.A.3 Swine][Other (please specify)][Tokelau_Swine] (Part 3 of 3)

[Sectors/Totals][3. Agriculture][3.1 Livestock][3.A Enteric Fermentation][3.A.3 Swine] [Other (please specify)][Pigs]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Population	1000s	2.4	2.362	2.219	2.076	1.933	1.79	1.647	1.647	1.647	1.647	1.647
Average gross energy intake	MJ/head/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Average CH_4 conversion rate	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

[Sectors/Totals][3. Agriculture][3.1 Livestock][3.A Enteric Fermentation][3.A.3 Swine] [Other (please specify)][Pigs]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Method												
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information												
CH_4		D	D	D	D	D	D	D	D	D	D	D
Emissions												
CH_4	kt	0.004	0.004	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002
Implied emission factor												
CH_4	kg/head/year	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Additional information												
Weight	kg	80	80	80	80	80	80	80	80	80	80	80
Feeding situation		Pen	Pen	Pen	Pen	Pen	Pen	Pen	Pen	Pen	Pen	Pen
Milk yield	kg/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Work	h/day	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Pregnant	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Digestibility of feed	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gross energy	MJ/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Tokelau CRF Table 3.A.4 Tokelau Poultry: [3. Agriculture][3.1 Livestock][3.A Enteric Fermentation][3.A.4 Other livestock][Tokelau_Poultry] (Part 1 of 3)

[Sectors/Totals][3. Agriculture][3.1 Livestock][3.A Enteric Fermentation][3.A.4 Other livestock] [Poultry]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Population	1000s	3.439	3.5	3.394	3.288	3.182	3.076	2.97	2.84	2.709	2.579
Average gross energy intake	MJ/head/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Average CH_4 conversion rate	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Method											
CH_4		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emission factor information											
CH_4		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emissions											

[Sectors/Totals][3. Agriculture][3.1 Livestock][3.A Enteric Fermentation][3.A.4 Other livestock] [Poultry]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CH_4	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Implied emission factor											
CH_4	kg/head/year	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Additional information											
Weight	kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Feeding situation		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Milk yield	kg/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Work	h/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pregnant	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Digestibility of feed	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gross energy	MJ/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Tokelau CRF Table 3.A.4 Tokelau Poultry: [3. Agriculture][3.1 Livestock][3.A Enteric Fermentation][3.A.4 Other livestock][Tokelau_Poultry] (Part 2 of 3)

[Sectors/Totals][3. Agriculture][3.1 Livestock][3.A Enteric Fermentation][3.A.4 Other livestock] [Poultry]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Population	1000s	2.448	2.318	2.229	2.14	2.052	1.963	1.874	1.712	1.55	1.388
Average gross energy intake	MJ/head/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Average CH_4 conversion rate	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Method											
CH_4		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emission factor information											
CH_4		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emissions											
CH_4	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Implied emission factor											
CH_4	kg/head/year	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Additional information											
Weight	kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Feeding situation		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

[Sectors/Totals][3. Agriculture][3.1 Livestock][3.A Enteric Fermentation][3.A.4 Other livestock] [Poultry]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Milk yield	kg/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Work	h/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pregnant	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Digestibility of feed	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gross energy	MJ/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Tokelau CRF Table 3.A.4 Tokelau Poultry: [3. Agriculture][3.1 Livestock][3.A Enteric Fermentation][3.A.4 Other livestock][Tokelau_Poultry] (Part 3 of 3)

[Sectors/Totals][3. Agriculture][3.1 Livestock][3.A Enteric Fermentation][3.A.4 Other livestock][Poultry]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Population	1000s	1.226	1.064	0.976	0.888	0.801	0.713	0.625	0.625	0.625	0.625	0.625
Average gross energy intake	MJ/head/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Average CH_4 conversion rate	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Method												
CH_4		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emission factor information												
CH_4		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emissions												
CH_4	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Implied emission factor												
CH_4	kg/head/year	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Additional information												
Weight	kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Feeding situation		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Milk yield	kg/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Work	h/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pregnant	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Digestibility of feed	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gross energy	MJ/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Tokelau CRF Table 3.B.1.3 Tokelau Swine: [3. Agriculture][3.1 Livestock][3.B Manure Management][3.B.1 CH4 Emissions][3.B.1.3 Swine][Other (please specify)][Pigs] (Part 1 of 3)

[Sectors/Totals][3. Agriculture][3.1 Livestock][3.B Manure Management][3.B.1 CH4 Emissions] [3.B.1.3 Swine][Other (please specify)][Pigs]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Population	1000s	2.293	2.5	2.395	2.29	2.186	2.081	1.976	2.111	2.247	2.382
Allocation by climate region											
Warm	%	100	100	100	100	100	100	100	100	100	100
Typical animal mass (average)	kg	80	80	80	80	80	80	80	80	80	80
VS daily excretion (average)	kg dm/head/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4 producing potential (average)	m^3/kg VS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Method											
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CH_4		D	D	D	D	D	D	D	D	D	D
Emissions											
CH_4	kt	0.042	0.046	0.044	0.042	0.04	0.038	0.037	0.039	0.042	0.044
Implied emission factor											
CH_4	kg/head/year	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5

Tokelau CRF Table 3.B.1.3 Tokelau Swine: [3. Agriculture][3.1 Livestock][3.B Manure Management][3.B.1 CH4 Emissions][3.B.1.3 Swine][Other (please specify)][Pigs] (Part 2 of 3)

[Sectors/Totals][3. Agriculture][3.1 Livestock][3.B Manure Management][3.B.1 CH4 Emissions][3.B.1.3 Swine][Other (please specify)][Pigs]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Population	1000s	2.518	2.653	2.633	2.613	2.592	2.572	2.552	2.514	2.476	2.438
Allocation by climate region											
Warm	%	100	100	100	100	100	100	100	100	100	100
Typical animal mass (average)	kg	80	80	80	80	80	80	80	80	80	80
VS daily excretion (average)	kg dm/head/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4 producing potential (average)	m^3/kg VS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Method											
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1

[Sectors/Totals][3. Agriculture][3.1 Livestock][3.B Manure Management][3.B.1 CH4 Emissions][3.B.1.3 Swine][Other (please specify)][Pigs]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Emission factor information											
CH_4		D	D	D	D	D	D	D	D	D	D
Emissions											
CH_4	kt	0.047	0.049	0.049	0.048	0.048	0.048	0.047	0.047	0.046	0.045
Implied emission factor											
CH_4	kg/head/year	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5

Tokelau CRF Table 3.B.1.3 Tokelau Swine: [3. Agriculture][3.1 Livestock][3.B Manure Management][3.B.1 CH4 Emissions][3.B.1.3 Swine][Other (please specify)][Pigs] (Part 3 of 3)

[Sectors/Totals][3. Agriculture][3.1 Livestock][3.B Manure Management][3.B.1 CH4 Emissions][3.B.1.3 Swine][Other (please specify)][Pigs]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Population	1000s	2.4	2.362	2.219	2.076	1.933	1.79	1.647	1.647	1.647	1.647	1.647
Allocation by climate region												
Warm	%	100	100	100	100	100	100	100	100	101	102	103
Typical animal mass (average)	kg	80	80	80	80	80	80	80	80	80	80	80
VS daily excretion (average)	kg dm/head/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4 producing potential (average)	m^3/kg VS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Method												
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information												
CH_4		D	D	D	D	D	D	D	D	D	D	D
Emissions												
CH_4	kt	0.044	0.044	0.041	0.038	0.036	0.033	0.03	0.03	0.03	0.03	0.03
Implied emission factor												
CH_4	kg/head/year	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5

Tokelau CRF Table 3.B.1.4 Tokelau Poultry: [3. Agriculture][3.1 Livestock][3.B Manure Management][3.B.1 CH4 Emissions][3.B.1.4 Other livestock][Tokelau_Poultry] (Part 1 of 3)

[Sectors/Totals][3. Agriculture][3.1 Livestock][3.B Manure Management][3.B.1 CH4 Emissions][3.B.1.4 Other livestock][Poultry]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Population	1000s	3.439	3.5	3.394	3.288	3.182	3.076	2.97	2.84	2.709	2.579
Allocation by climate region											
Cool	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Temperate	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Warm	%	100	100	100	100	100	100	100	100	100	100
Typical animal mass (average)	kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
VS daily excretion (average)	kg dm/head/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4 producing potential (average)	m^3/kg VS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Method											
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CH_4		D	D	D	D	D	D	D	D	D	D
Emissions											
CH_4	kt	0.0001032	0.000105	0.0001018	0.0000986	0.0000955	0.0000923	0.0000891	0.0000852	0.0000813	0.0000774
Implied emission factor											
CH_4	kg/head/year	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03

Tokelau CRF Table 3.B.1.4 Tokelau Poultry: [3. Agriculture][3.1 Livestock][3.B Manure Management][3.B.1 CH4 Emissions][3.B.1.4 Other livestock][Tokelau_Poultry] (Part 2 of 3)

[Sectors/Totals][3. Agriculture][3.1 Livestock][3.B Manure Management][3.B.1 CH4 Emissions][3.B.1.4 Other livestock][Poultry]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Population	1000s	2.448	2.318	2.229	2.14	2.052	1.963	1.874	1.712	1.55	1.388
Allocation by climate region											
Cool	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Temperate	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Warm	%	100	100	100	100	100	100	100	100	100	100

[Sectors/Totals][3. Agriculture][3.1 Livestock][3.B Manure Management][3.B.1 CH4 Emissions][3.B.1.4 Other livestock][Poultry]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Typical animal mass (average)	kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
VS daily excretion (average)	kg dm/head/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4 producing potential (average)	m^3/kg VS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Method											
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CH_4		D	D	D	D	D	D	D	D	D	D
Emissions											
CH_4	kt	0.0000735	0.0000695	0.0000669	0.0000642	0.0000615	0.0000589	0.0000562	0.0000514	0.0000465	0.0000416
Implied emission factor											
CH_4	kg/head/year	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03

Tokelau CRF Table 3.B.1.4 Tokelau Poultry: [3. Agriculture][3.1 Livestock][3.B Manure Management][3.B.1 CH4 Emissions][3.B.1.4 Other livestock][Tokelau_Poultry] (Part 3 of 3)

[Sectors/Totals][3. Agriculture][3.1 Livestock][3.B Manure Management][3.B.1 CH4 Emissions][3.B.1.4 Other livestock][Poultry]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Population	1000s	1.226	1.064	0.976	0.888	0.801	0.713	0.625	0.625	0.625	0.625	0.625
Allocation by climate region												
Cool	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Temperate	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Warm	%	100	100	100	100	100	100	100	100	100	100	100
Typical animal mass (average)	kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
VS daily excretion (average)	kg dm/head/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4 producing potential (average)	m^3/kg VS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Method												
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1

[Sectors/Totals][3. Agriculture][3.1 Livestock][3.B Manure Management][3.B.1 CH4 Emissions][3.B.1.4 Other livestock][Poultry]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Emission factor information												
CH_4		D	D	D	D	D	D	D	D	D	D	D
Emissions												
CH_4	kt	0.0000368	0.0000319	0.0000293	0.0000267	0.000024	0.0000214	0.0000187	0.0000187	0.0000187	0.0000187	0.0000187
Implied emission factor												
CH_4	kg/head/year	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03

Tokelau CRF Table 5.A: [5. Waste][5.A Solid Waste Disposal] (Part 1 of 3)

[5. Waste][5.A Solid Waste Disposal]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Method											
CO_2		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CO_2		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4		D	D	D	D	D	D	D	D	D	D
Emissions	kt CO_2-equivalent	0.394	0.391	0.388	0.385	0.383	0.38	0.378	0.376	0.373	0.371
CO_2	kt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4	kt	0.016	0.016	0.016	0.015	0.015	0.015	0.015	0.015	0.015	0.015
NO_x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

Tokelau CRF Table 5.A: [5. Waste][5.A Solid Waste Disposal] (Part 2 of 3)

[5. Waste][5.A Solid Waste Disposal]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Method											
CO_2		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CO_2		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4		D	D	D	D	D	D	D	D	D	D
Emissions	kt CO_2-equivalent	0.369	0.366	0.364	0.359	0.353	0.346	0.338	0.328	0.321	0.315
CO_2	kt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4	kt	0.015	0.015	0.015	0.014	0.014	0.014	0.014	0.013	0.013	0.013
NO_x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

Tokelau CRF Table 5.A: [5. Waste][5.A Solid Waste Disposal] (Part 3 of 3)

[5. Waste][5.A Solid Waste Disposal]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Method												
CO_2		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information												
CO_2		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4		D	D	D	D	D	D	D	D	D	D	D
Emissions	kt CO_2-equivalent	0.31	0.307	0.304	0.303	0.302	0.302	0.303	0.304	0.305	0.306	0.307
CO_2	kt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4	kt	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
NO_x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

Tokelau CRF Table 5.A.3: [5. Waste][5.A Solid Waste Disposal][5.A.3 Uncategorized Waste Disposal Sites] (Part 1 of 3)

[5. Waste][5.A Solid Waste Disposal][5.A.3 Uncategorized Waste Disposal Sites]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Annual waste at the SWDS	kt	0.541	0.53	0.528	0.526	0.524	0.522	0.52	0.516	0.512	0.508
MCF		0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
DOCf	%	50	50	50	50	50	50	50	50	50	50
Method											
CO_2		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CO_2		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4		D	D	D	D	D	D	D	D	D	D
Emissions											
CO_2	kt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4											
Emissions	kt	0.016	0.016	0.016	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Amount of CH_4 flared	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Amount of CH_4 for energy recovery	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
NO_x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Implied emission factor											
CO_2	t/t	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4	t/t	0.029	0.03	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029

Tokelau CRF Table 5.A.3: [5. Waste][5.A Solid Waste Disposal][5.A.3 Uncategorized Waste Disposal Sites] (Part 2 of 3)

[5. Waste][5.A Solid Waste Disposal][5.A.3 Uncategorized Waste Disposal Sites]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Annual waste at the SWDS	kt	0.504	0.5	0.479	0.459	0.438	0.418	0.397	0.401	0.405	0.408
MCF		0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
DOCf	%	50	50	50	50	50	50	50	50	50	50
Method											
CO_2		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CO_2		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4		D	D	D	D	D	D	D	D	D	D
Emissions											
CO_2	kt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4											
Emissions	kt	0.015	0.015	0.015	0.014	0.014	0.014	0.014	0.013	0.013	0.013
Amount of CH_4 flared	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Amount of CH_4 for energy recovery	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
NO_x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Implied emission factor											
CO_2	t/t	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4	t/t	0.029	0.029	0.03	0.031	0.032	0.033	0.034	0.033	0.032	0.031

Tokelau CRF Table 5.A.3: [5. Waste][5.A Solid Waste Disposal][5.A.3 Uncategorized Waste Disposal Sites] (Part 3 of 3)

[5. Waste][5.A Solid Waste Disposal][5.A.3 Uncategorized Waste Disposal Sites]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Annual waste at the SWDS	kt	0.412	0.416	0.421	0.427	0.432	0.438	0.443	0.443	0.443	0.447	0.447
MCF		0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
DOCf	%	50	50	50	50	50	50	50	50	50	50	50
Method												
CO_2		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information												
CO_2		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4		D	D	D	D	D	D	D	D	D	D	D
Emissions												
CO_2	kt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4												
Emissions	kt	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
Amount of CH_4 flared	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Amount of CH_4 for energy recovery	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
NO_x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Implied emission factor												
CO_2	t/t	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4	t/t	0.03	0.03	0.029	0.028	0.028	0.028	0.027	0.027	0.028	0.027	0.027

Tokelau CRF Table 5.C.2.2.a: [5. Waste][5.C Incineration and Open Burning of Waste][5.C.2 Open Burning of Waste][5.C.2.2 Non-biogenic][5.C.2.2.a Municipal Solid Waste] (Part 1 of 3)

[5. Waste][5.C Incineration and Open Burning of Waste][5.C.2 Open Burning of Waste][5.C.2.2 Non-biogenic][5.C.2.2.a Municipal Solid Waste]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Amount of wastes incinerated/open burned	kt	0.541	0.53	0.528	0.526	0.524	0.522	0.52	0.516	0.512	0.508
Method											
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CO_2		D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions											
CO_2	kt	0.047	0.046	0.046	0.046	0.045	0.045	0.045	0.045	0.044	0.044
CH_4	kt	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
N_2O	kt	0.0000455	0.0000446	0.0000445	0.0000443	0.0000441	0.0000439	0.0000438	0.0000434	0.0000431	0.0000428
Implied emission factor											
CO_2	kg/t	86.728	86.728	86.728	86.728	86.728	86.728	86.728	86.728	86.728	86.728
CH_4	kg/t	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
N_2O	kg/t	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084

Tokelau CRF Table 5.C.2.2.a: [5. Waste][5.C Incineration and Open Burning of Waste][5.C.2 Open Burning of Waste][5.C.2.2 Non-biogenic][5.C.2.2.a Municipal Solid Waste] (Part 2 of 3)

[5. Waste][5.C Incineration and Open Burning of Waste][5.C.2 Open Burning of Waste][5.C.2.2 Non-biogenic][5.C.2.2.a Municipal Solid Waste]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Amount of wastes incinerated/open burned	kt	0.504	0.5	0.479	0.459	0.438	0.418	0.397	0.401	0.405	0.408
Method											
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1

[5. Waste][5.C Incineration and Open Burning of Waste][5.C.2 Open Burning of Waste][5.C.2.2 Non-biogenic][5.C.2.2.a Municipal Solid Waste]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Emission factor information											
CO_2		D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions											
CO_2	kt	0.044	0.043	0.042	0.04	0.038	0.036	0.034	0.035	0.035	0.035
CH_4	kt	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
N_2O	kt	0.0000424	0.0000421	0.0000404	0.0000386	0.0000369	0.0000352	0.0000334	0.0000337	0.0000341	0.0000344
Implied emission factor											
CO_2	kg/t	86.728	86.728	86.728	86.728	86.728	86.728	86.728	86.728	86.728	86.728
CH_4	kg/t	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
N_2O	kg/t	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084

Tokelau CRF Table 5.C.2.2.a: [5. Waste][5.C Incineration and Open Burning of Waste][5.C.2 Open Burning of Waste][5.C.2.2 Non-biogenic][5.C.2.2.a Municipal Solid Waste] (Part 3 of 3)

[5. Waste][5.C Incineration and Open Burning of Waste][5.C.2 Open Burning of Waste][5.C.2.2 Non-biogenic][5.C.2.2.a Municipal Solid Waste]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Amount of wastes incinerated/open burned	kt	0.412	0.416	0.421	0.427	0.432	0.438	0.443	0.443	0.443	0.447	0.447
Method												
CO_2		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information												
CO_2		D	D	D	D	D	D	D	D	D	D	D
CH_4		D	D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D	D

[5. Waste][5.C Incineration and Open Burning of Waste][5.C.2 Open Burning of Waste][5.C.2.2 Non-biogenic][5.C.2.2.a Municipal Solid Waste]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Emissions												
CO_2	kt	0.036	0.036	0.037	0.037	0.037	0.038	0.038	0.038	0.038	0.039	0.039
CH_4	kt	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
N_2O	kt	0.0000347	0.000035	0.0000355	0.0000359	0.0000364	0.0000369	0.0000373	0.0000373	0.0000373	0.0000376	0.0000376
Implied emission factor												
CO_2	kg/t	86.728	86.728	86.728	86.728	86.728	86.728	86.728	86.728	86.728	86.728	86.728
CH_4	kg/t	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
N_2O	kg/t	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084

Tokelau CRF Table 5.D:[5. Waste][5.D Wastewater Treatment and Discharge] (Part 1 of 3)

[5. Waste][5.D Wastewater Treatment and Discharge]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Method											
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CH_4		D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions	kt CO_2-equivalent	0.166	0.168	0.173	0.179	0.184	0.189	0.195	0.207	0.22	0.232
CH_4	kt	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.009
N_2O	kt	0.0000593	0.0000562	0.0000537	0.0000511	0.0000486	0.0000461	0.0000436	0.0000379	0.0000323	0.0000268
No_2x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Additional information											
Population	1000s	1.568	1.537	1.531	1.525	1.519	1.513	1.507	1.495	1.484	1.472
Protein consumption	kg/person/yr	32.448	32.448	32.448	32.448	32.448	32.448	32.448	32.448	32.448	32.448

[5. Waste][5.D Wastewater Treatment and Discharge]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Fraction of nitrogen in protein		0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Factor of non-consumed protein added to the wastewater		1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Factor of industrial and commercial co-discharged protein into the sewer system		1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Degree of utilization of modern, centralized WWT plants	%	0	0	0	0	0	0	0	0	0	0

Tokelau CRF Table 5.D:[5. Waste][5.D Wastewater Treatment and Discharge] (Part 2 of 3)

[5. Waste][5.D Wastewater Treatment and Discharge]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Method											
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CH_4		D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions	kt CO_2-equivalent	0.244	0.255	0.247	0.239	0.23	0.221	0.212	0.216	0.219	0.223
CH_4	kt	0.009	0.01	0.01	0.009	0.009	0.009	0.008	0.009	0.009	0.009
N_2O	kt	0.0000214	0.000016	0.0000145	0.0000131	0.0000117	0.0000104	0.0000092	0.0000087	0.0000081	0.0000075
No_2x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Additional information											
Population	1000s	1.461	1.449	1.389	1.33	1.27	1.211	1.151	1.162	1.173	1.183
Protein consumption	kg/person/yr	32.448	32.448	32.448	32.448	32.448	32.448	32.448	32.448	32.448	32.448
Fraction of nitrogen in protein		0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Factor of non-consumed protein added to the wastewater		1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Factor of industrial and commercial co-discharged protein into the sewer system		1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Degree of utilization of modern, centralized WWT plants	%	0	0	0	0	0	0	0	0	0	0

Tokelau CRF Table 5.D:[5. Waste][5.D Wastewater Treatment and Discharge] (Part 3 of 3)

[5. Waste][5.D Wastewater Treatment and Discharge]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Method												
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information												
CH_4		D	D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D	D
Emissions	kt CO_2-equivalent	0.227	0.231	0.237	0.244	0.25	0.257					
CH_4	kt	0.009	0.009	0.009	0.01	0.01	0.01	0.011	0.011	0.011	0.011	0.011
N_2O	kt	0.0000069	0.0000063	0.0000051	0.0000039	0.0000026	0.0000013	NO	NO	NO	NO	NO
No_2x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Additional information												
Population	1000s	1.194	1.205	1.221	1.237	1.253	1.269	1.285	1.285	1.285	1.295	1.295
Protein consumption	kg/person/yr	32.448	32.448	32.448	32.448	32.448	32.448	32.448	32.448	32.448	32.448	32.448
Fraction of nitrogen in protein		0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Factor of non-consumed protein added to the wastewater		1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Factor of industrial and commercial co-discharged protein into the sewer system		1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Degree of utilization of modern, centralized WWT plants	%	0	0	0	0	0	0	0	0	1	2	3

Tokelau CRF Table 5.D.1: [5. Waste][5.D Wastewater Treatment and Discharge][5.D.1 Domestic Wastewater] (Part 1 of 3)

[5. Waste][5.D Wastewater Treatment and Discharge][5.D.1 Domestic Wastewater]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total organic product	kt DC	0.043	0.042	0.042	0.042	0.042	0.041	0.041	0.041	0.041	0.04
Sludge removed	kt DC	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
N in effluent	kt	0.008	0.007	0.007	0.007	0.006	0.006	0.006	0.005	0.004	0.003
Method											
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CH_4		D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions											
CH_4											
Emissions	kt	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.009
Amount of CH_4 flared	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Amount of CH_4 for energy recovery	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
N_2O	kt	0.0000593	0.0000562	0.0000537	0.0000511	0.0000486	0.0000461	0.0000436	0.0000379	0.0000323	0.0000268
NO_x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Implied emission factor											
CH_4	kg/kg DC	0.138	0.144	0.15	0.157	0.163	0.17	0.176	0.191	0.207	0.222
N_2O	kg N_2O-N/kg N	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005

Tokelau CRF Table 5.D.1: [5. Waste][5.D Wastewater Treatment and Discharge][5.D.1 Domestic Wastewater] (Part 2 of 3)

[5. Waste][5.D Wastewater Treatment and Discharge][5.D.1 Domestic Wastewater]	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total organic product	kt DC	0.04	0.04	0.038	0.036	0.035	0.033	0.032	0.032	0.032	0.032
Sludge removed	kt DC	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
N in effluent	kt	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.0009546
Method											
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information											
CH_4		D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D
Emissions											
CH_4											
Emissions	kt	0.009	0.01	0.01	0.009	0.009	0.009	0.008	0.009	0.009	0.009
Amount of CH_4 flared	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Amount of CH_4 for energy recovery	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
N_2O	kt	0.0000214	0.000016	0.0000145	0.0000131	0.0000117	0.0000104	0.0000092	0.0000087	0.0000081	0.0000075
No_x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Implied emission factor											
CH_4	kg/kg DC	0.237	0.253	0.255	0.258	0.26	0.263	0.266	0.268	0.27	0.273
N_2O	kg N_2O-N/kg N	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005

Tokelau CRF Table 5.D.1: [5. Waste][5.D Wastewater Treatment and Discharge][5.D.1 Domestic Wastewater] (Part 3 of 3)

[5. Waste][5.D Wastewater Treatment and Discharge][5.D.1 Domestic Wastewater]	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total organic product	kt DC	0.033	0.033	0.033	0.034	0.034	0.035	0.035	0.035	0.035	0.035	0.035
Sludge removed	kt DC	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
N in effluent	kt	0.0008781	0.0008	0.0006485	0.0004927	0.0003327	0.0001685	NO	NO	NO	NO	NO
Method												
CH_4		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N_2O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information												
CH_4		D	D	D	D	D	D	D	D	D	D	D
N_2O		D	D	D	D	D	D	D	D	D	D	D
Emissions												
CH_4												
Emissions	kt	0.009	0.009	0.009	0.01	0.01	0.01	0.011	0.011	0.011	0.011	0.011
Amount of CH_4 flared	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Amount of CH_4 for energy recovery	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
N_2O	kt	0.0000069	0.0000063	0.0000051	0.0000039	0.0000026	0.0000013	NO	NO	NO	NO	NO
No_x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Implied emission factor												
CH_4	kg/kg DC	0.275	0.278	0.282	0.287	0.291	0.296	0.3	0.3	0.3	0.3	0.3
N_2O	kg N_2O-N/kg N	0.005	0.005	0.005	0.005	0.005	0.005	NO	NO	NO	NO	NO

Annex 8: Agricultural emissions from fertilisers and by livestock type

A8.1 Agricultural emissions from fertilisers

Fertilisers provide the nutrients to grow and nourish pastures and crops. Nitrogen, phosphate, potassium and sulphur are the four most important nutrients for pasture and crop yields and sustainable food production.

New Zealand's farmers use both organic and synthetic nitrogen (N) fertilisers. The main types of synthetic N fertilisers used in New Zealand are urea, followed by smaller amounts of diammonium phosphate (DAP) and ammonium sulphate. Urea is mainly applied to dairy pasture land to boost pasture growth during the autumn and spring months.

All nitrogen fertilisers provide N inputs to agricultural soils that result in direct and indirect emissions of nitrous oxide (N_2O) (see figure 5.5.1 in chapter 5). Urea also releases carbon dioxide (CO_2).

Emissions from organic fertilisers come solely from animal manure. Most animal manure in New Zealand is excreted directly onto pasture, but some manure from dairy farms is kept in manure management systems and applied to soils as an organic fertiliser (see table 5.3.2 in chapter 5, for further details). Some manure is also collected but not stored; rather, it is spread directly onto pasture daily (e.g., swine manure and some dairy manure).

Emissions of N_2O from all synthetic (including urea) N fertilisers are reported in categories 3.D.1.1 and 3.D.1.2 respectively. Emissions of CO_2 from urea are not included under synthetic N fertilisers and are reported under a dedicated category 3.H.

2020

In 2020, the combined effect of synthetic and organic N fertilisers amounted to 24.9 per cent of emissions from the *Agricultural soils* category and 6.3 per cent from all agricultural emissions (when CO_2-e from urea is included).

Table A8.1.1 shows comparisons of both N_2O and CO_2 emissions from fertilisers to New Zealand's national totals for each gas and New Zealand's gross emissions.

Table A8.1.1 Direct and indirect emissions by fertiliser in 2020

Fertiliser type	Gas/source	Emissions kt CO_2-e	Percentage of: N_2O emissions from Agriculture soils by gas (%)	Percentage of: All emissions from Agriculture (%)
Synthetic N fertiliser	Direct N_2O emissions	1,548.2	19.6	3.9
	Urea	939.4	11.9	2.4
	Other synthetic N fertilisers	608.8	7.7	1.5
	Indirect N_2O emissions from all synthetic N fertilisers	305.7	**3.9**	**0.8**
	All N_2O (direct + indirect) from synthetic N fertilisers	1,853.9	23.5	4.7
	CO_2 from urea	542.0	NA	1.4

Fertiliser type	Gas/source	Emissions kt CO_2-e	Percentage of: N_2O emissions from Agriculture soils by gas (%)	Percentage of: All emissions from Agriculture (%)
Organic fertiliser	Direct N_2O emissions	76.2	1.0	0.2
	Indirect N_2O emissions	30.6	0.4	0.1
	All N_2O (direct + indirect) from organic fertilisers	106.8	1.4	0.3

Note: NA = not applicable. Columns may not add up due to rounding.

1990–2020

The total amount of fertilisers applied to agricultural soils in New Zealand has significantly increased since 1990. Synthetic N fertiliser applied to agricultural land has increased by 693 per cent since 1990, while the use of organic fertiliser has grown by 173.6 per cent (table A8.1.2).

Table A8.1.2 Use of fertilisers in New Zealand in 1990 and 2020

	1990			2020			Change in the use between 1990 and 2020	
	Application	Percentage of		Application	Percentage of			
Fertiliser type	tonnes (N)	synthetic N fertiliser (%)	all fertilisers (%)	tonnes (N)	synthetic N fertiliser (%)	all fertilisers (%)	tonnes (N)	(%)
Synthetic N fertiliser (ammonium phosphates, for example, DAP)	34,679	58.5	46.3	130,000	27.7	25.4	95,321	274.9
Urea	24,586	41.5	32.8	340,000	72.3	66.3	315,414	1,282.9
Total synthetic N fertilisers (urea + ammonium phosphates)	59,265	100.0	79.1	470,000	100.0	91.7	410,735	693.0
Organic fertilisers (animal manure applied to soils)	15,644	NA	20.9	42,803	NA	8.3	27,159	173.6

Note: DAP = diammonium phosphate; NA = not applicable. Columns may not add up due to rounding.

Between 1990 and 2020, N_2O emissions from synthetic N fertiliser (both direct and indirect emissions, including urea) have increased by 579.9 per cent, while total emissions from these fertilisers (N_2O and CO_2) have increased by 668.3 per cent. For the same period, total emissions from organic fertilisers increased by 125.1 per cent (see table A8.1.3).

In 1990 and 2020 respectively, 0.8 per cent and 4.7 per cent of total agricultural emissions originated from N_2O from synthetic N fertiliser. Total emissions from synthetic N fertiliser (including urea) have increased from 0.9 per cent to 6.1 per cent of total agricultural emissions for 1990 and 2020 respectively (see chapter 5 for further details).

Table A8.1.3 Emissions from fertilisers in 1990 and 2020

			Synthetic N fertilisers	Organic fertilisers
1990	N_2O emissions	kt CO_2-e	272.6	47.4
	CO_2 emissions	kt	39.2	NA
	Total emissions	**kt CO_2-e**	**311.8**	**47.4**
2020	N_2O emissions	kt CO_2-e	1,853.9	106.8
	CO_2 emissions	kt	542.0	NA
	Total emissions	**kt CO_2-e**	**2,395.9**	**106.8**

		Synthetic N fertilisers	Organic fertilisers
Change in N_2O emissions between 1990 and 2020	kt CO_2-e	1,581.2	59.3
Percentage change in N_2O emissions between 1990 and 2020	%	579.9	125.1
Change in all emissions between 1990 and 2020	kt CO_2-e	2,084.1	59.3
Percentage change in all emissions between 1990 and 2020	%	668.3	125.1

Note: NA = not applicable.

A8.2 Agricultural emissions by livestock type

This section covers distribution of all greenhouse gas emissions from the Agriculture sector by livestock type in 1990, 2019 and 2020, including the changes in emissions. Table A8.2.1 shows total emissions of all greenhouse gases across all categories of the Agriculture sector. For further details on emissions by gas and by category, refer to the common reporting format tables (sector 3 – Agriculture).

Table A8.2.1 Total emissions by livestock type in 1990, 2019 and 2020

	1990	2019	2020	1990–2020		2019–2020	
Livestock type		kt CO_2-e		kt CO_2-e	(%)	kt CO_2-e	(%)
Dairy cattle	8,006.5	18,450.6	18,481.8	10,475.3	130.8	31.2	0.2
Beef cattle	7,040.6	7,018.0	7,102.0	61.3	0.9	84.0	1.2
Sheep	16,278.4	9,576.4	9,308.2	–6,970.2	–42.8	–268.3	–2.8
Deer	517.4	569.8	573.7	56.3	10.9	3.9	0.7
Swine	102.0	71.5	65.5	–36.5	–35.8	–6.0	–8.4
Goats	262.8	27.9	28.7	–234.0	–89.1	0.8	3.0
Horses	78.4	32.0	32.2	–46.1	–58.9	0.2	0.5
Alpaca	0.1	2.8	2.6	2.5	2,259.2	–0.2	–8.0
Mules and asses	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Poultry (including all types of poultry)	26.3	59.4	59.5	33.2	126.2	0.1	0.2
Total, all livestock types	**32,312.5**	**35,808.5**	**35,654.3**	**3,341.8**	**9.4**	**154.2**	**–0.4**

Note: Columns may not add up due to rounding.