1990–2022 | Volume 2, annexes

Te Rārangi Haurehu Kati Mahana a Aotearoa

New Zealand's Greenhouse Gas Inventory

Fulfilling reporting requirements under the United Nations Framework Convention on Climate Change and the Paris Agreement

Ministry for the Environment
Manatū Mō Te Taiao

Te Kāwanatanga o Aotearoa
New Zealand Government

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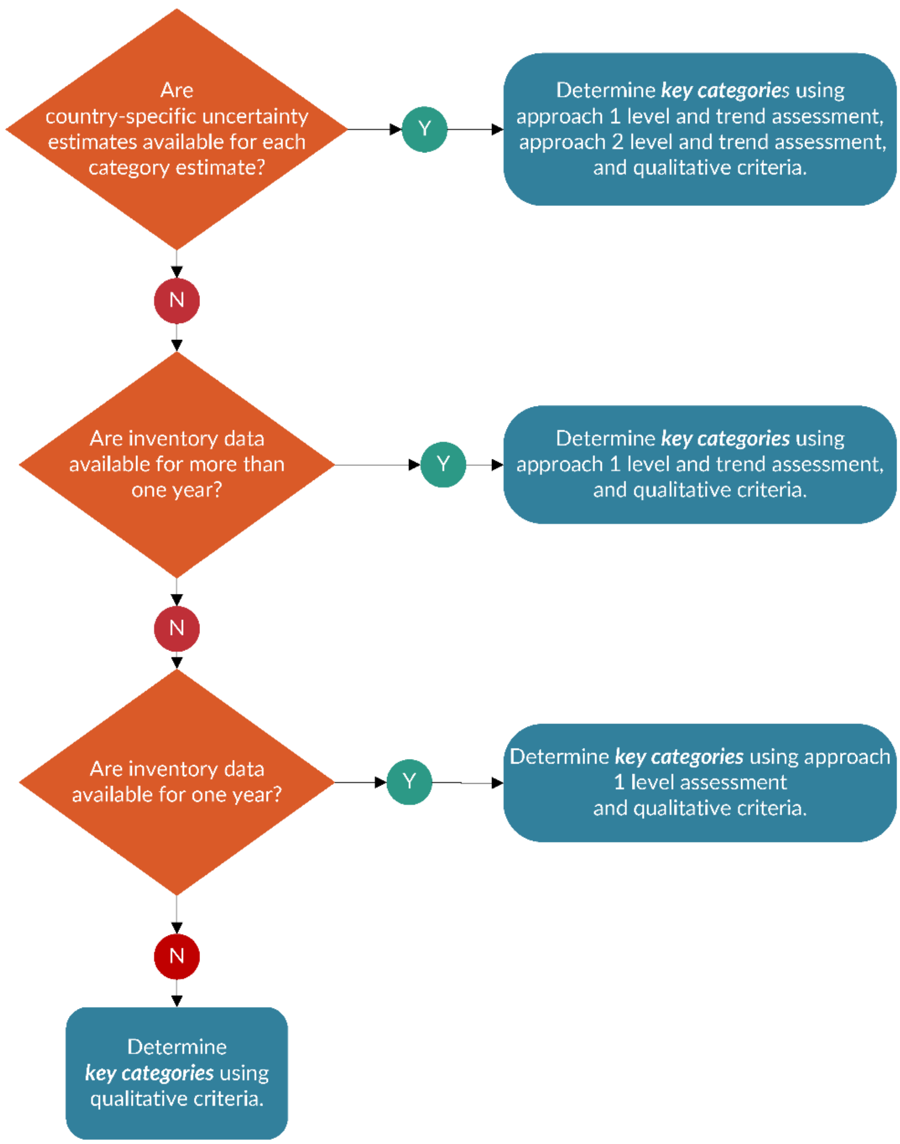
Annex 1: Key categories

A1.1 Methodology used for identifying key categories

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

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



The analysis was carried out both 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 2006 IPCC Guidelines (IPCC, 2006).

A1.2 Disaggregation

The classification of categories follows the classification of the common reporting tables (CRTs) 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 2006 IPCC 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 CRTs 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 CRTs. This allows for a more evenly proportioned analysis of categories.

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

The following tables specify the level and trend analyses of net and gross emissions and removals for 2022 and 1990. 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 2022 level and the trend analysis are key categories, as indicated in the shaded and bold cells.

Table A1.3.1(a) and table A1.3.1(b) present results of the key category level analysis of the net and gross emissions and removals in 2022 respectively.

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 2022

CRT category code	IPCC category	Gas	2022 estimate (kt CO_2-equivalent)	Level assessment (%)	Cumulative total (%)
3.A.1	**Option A – Dairy Cattle**	**CH_4**	**15,992.6**	**14.9**	**14.9**
4.A.1	**Forest Land – Forest Land Remaining Forest Land**	**CO_2**	**-15,021.1**	**14.0**	**28.9**
1.A.3.b	**Transport – Road Transportation**	**CO_2**	**12,352.6**	**11.5**	**40.4**
3.A.2	**Other (please specify) – Sheep**	**CH_4**	**8,865.5**	**8.3**	**48.6**
3.A.1	**Option A – Non-dairy Cattle**	**CH_4**	**7,203.1**	**6.7**	**55.3**
4.G	**Land Use, Land-Use Change and Forestry – Harvested Wood Products**	**CO_2**	**-6,582.3**	**6.1**	**61.5**
3.D.1.3	**Direct N_2O Emissions from Managed Soils – Urine and Dung Deposited by Grazing Animals**	**N_2O**	**3,255.5**	**3.0**	**64.5**
5.A	**Waste – Solid Waste Disposal**	**CH_4**	**2,840.6**	**2.6**	**67.1**
4.A.2	**Forest Land – Land Converted to Forest Land**	**CO_2**	**-2,511.4**	**2.3**	**69.5**
4.C.2	**Grassland – Land Converted to Grassland**	**CO_2**	**2,308.4**	**2.1**	**71.6**
1.A.1.a	**Energy Industries – Public Electricity and Heat Production**	**CO_2**	**1,977.4**	**1.8**	**73.5**

CRT category code	IPCC category	Gas	2022 estimate (kt CO_2-equivalent)	Level assessment (%)	Cumulative total (%)
2.C.1	**Metal Industry – Iron and Steel Production**	**CO_2**	**1,541.6**	**1.4**	**74.9**
3.B.1.1	**Cattle – Option A**	**CH_4**	**1,541.3**	**1.4**	**76.3**
2.F.1	**Product Uses as Substitutes for ODS – Refrigeration and Air Conditioning**	**HFCs**	**1,422.7**	**1.3**	**77.7**
1.A.2.e	**Food Processing, Beverages and Tobacco – Solid Fuels**	**CO_2**	**1,365.2**	**1.3**	**78.9**
1.A.4.b	**Other Sectors – Residential**	**CO_2**	**1,323.7**	**1.2**	**80.2**
4.C.1	**Grassland – Grassland Remaining Grassland**	**CO_2**	**1,315.3**	**1.2**	**81.4**
1.A.2.c	**Chemicals – Gaseous Fuels**	**CO_2**	**1,255.4**	**1.2**	**82.6**
1.A.4.c	**Other Sectors – Agriculture/Forestry/Fishing**	**CO_2**	**1,148.7**	**1.1**	**83.6**
1.A.3.a	**Domestic Aviation – Jet Kerosene**	**CO_2**	**994.7**	**0.9**	**84.5**
3.D.1.1	**Direct N_2O Emissions from Managed Soils – Inorganic N Fertilisers**	**N_2O**	**961.4**	**0.9**	**85.4**
1.A.2.e	**Food Processing, Beverages and Tobacco – Gaseous Fuels**	**CO_2**	**947.6**	**0.9**	**86.3**
1.A.4.a	**Other Sectors – Commercial/Institutional**	**CO_2**	**852.7**	**0.8**	**87.1**
3.D.2.1	**Indirect N_2O Emissions from Managed Soils – Atmospheric Deposition**	**N_2O**	**745.1**	**0.7**	**87.8**
1.A.1.a	**Energy Industries – Public Electricity and Heat Production**	**CO_2**	**716.0**	**0.7**	**88.5**
3.D.1.6	**Direct N_2O Emissions from Managed Soils – Cultivation of Organic Soils**	**N_2O**	**590.2**	**0.5**	**89.0**
2.C.3	**Metal Industry – Aluminium Production**	**CO_2**	**543.9**	**0.5**	**89.5**
1.A.2.g.v	**Other (please specify) – Construction**	**CO_2**	**516.2**	**0.5**	**90.0**
3.A.4	**Other Livestock – Deer**	**CH_4**	**508.0**	**0.5**	**90.5**
3.D.2.2	**Indirect N_2O Emissions from Managed Soils – Nitrogen Leaching and Run-off**	**N_2O**	**479.5**	**0.4**	**90.9**
3.G	**Agriculture – Liming**	**CO_2**	**445.6**	**0.4**	**91.4**
4.B.2	**Cropland – Land Converted to Cropland**	**CO_2**	**421.9**	**0.4**	**91.7**
1.B.2.d	**Other (please specify) – Geothermal**	**CO_2**	**419.5**	**0.4**	**92.1**
2.A.1	**Mineral Industry – Cement Production**	**CO_2**	**408.4**	**0.4**	**92.5**
3.H	**Agriculture – Urea Application**	**CO_2**	**404.9**	**0.4**	**92.9**
1.B.2.c.1.ii	**Venting – Gas**	**CO_2**	**404.9**	**0.4**	**93.3**
1.A.4.a	**Other Sectors – Commercial/Institutional**	**CO_2**	**403.6**	**0.4**	**93.6**
1.A.4.b	**Other Sectors – Residential**	**CO_2**	**366.5**	**0.3**	**94.0**
1.A.2.e	**Food Processing, Beverages and Tobacco – Liquid Fuels**	**CO_2**	**360.3**	**0.3**	**94.3**
1.A.2.g.iii	**Mining (excluding fuels) and Quarrying – Liquid Fuels**	**CO_2**	**335.1**	**0.3**	**94.6**
5.D	**Waste – Wastewater Treatment and Discharge**	**CH_4**	**287.4**	**0.3**	**94.9**
4.B.1	**Cropland – Cropland Remaining Cropland**	**CO_2**	**265.3**	**0.2**	**95.1**
3.D.1.4	Direct N_2O Emissions from Managed Soils – Crop Residues	N_2O	225.7	0.2	95.4
1.A.2.g.viii	Other (please specify) – Other (please specify)	CO_2	221.8	0.2	95.6
1.A.1.c	Energy Industries – Manufacture of Solid Fuels and Other Energy Industries	CO_2	195.6	0.2	95.7
1.A.2.f	Non-metallic Minerals – Solid Fuels	CO_2	187.2	0.2	95.9
1.A.1.b	Petroleum Refining – Liquid Fuels	CO_2	162.1	0.2	96.1
1.B.2.b.2	Natural Gas – Production	CH_4	140.2	0.1	96.2
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing	CO_2	139.2	0.1	96.3
1.A.2.d	Pulp, Paper and Print – Gaseous Fuels	CO_2	135.6	0.1	96.5
1.A.2.f	Non-metallic Minerals – Gaseous Fuels	CO_2	123.7	0.1	96.6

CRT category code	IPCC category	Gas	2022 estimate (kt CO_2-equivalent)	Level assessment (%)	Cumulative total (%)
1.A.3.c	Railways – Liquid Fuels	CO_2	115.2	0.1	96.7
1.B.2.d	Other (please specify) – Geothermal	CH_4	113.1	0.1	96.8
5.D	Waste – Wastewater Treatment and Discharge	N_2O	107.6	0.1	96.9
1.A.2.a	Iron and Steel – Gaseous Fuels	CO_2	103.2	0.1	97.0
2.A.2	Mineral Industry – Lime Production	CO_2	101.5	0.1	97.1
3.B.1.1	Cattle – Option A	CH_4	99.8	0.1	97.2
4.A	Forest Land – 4(II) Emissions and Removals from Drainage and Rewetting and Other Management of Organic and Mineral Soils	N_2O	98.1	0.1	97.3
3.B.1.2	CH_4 Emissions – Sheep	CH_4	96.9	0.1	97.4
2.G.3	Other Product Manufacture and Use – N_2O from Product Uses	N_2O	94.7	0.1	97.4
4.F.2	Other Land – Land Converted to Other Land	CO_2	87.0	0.1	97.5
3.B.2.5	N_2O and NMVOC Emissions – Indirect N_2O Emissions	N_2O	84.9	0.1	97.6
5.C	Waste – Incineration and Open Burning of Waste	CO_2	83.3	0.1	97.7
5.C	Waste – Incineration and Open Burning of Waste	CH_4	81.9	0.1	97.8
4.E.1	Settlements – Settlements Remaining Settlements	CO_2	78.8	0.1	97.8
2.B.8	Chemical Industry – Petrochemical and Carbon Black Production	CH_4	78.1	0.1	97.9
4.A.2	Forest Land – Land Converted to Forest Land	N_2O	74.9	0.1	98.0
1.A.3.b	Transport – Road Transportation	N_2O	72.8	0.1	98.0
1.A.2.g.iii	Mining (excluding fuels) and Quarrying – Solid Fuels	CO_2	71.7	0.1	98.1
1.A.2.f	Non-metallic Minerals – Liquid Fuels	CO_2	68.8	0.1	98.2
2.F.4	Product Uses as Substitutes for ODS – Aerosols	HFCs	67.8	0.1	98.2
3.D.1.2	Direct N_2O Emissions from Managed Soils – Organic N Fertilisers	N_2O	65.0	0.1	98.3
1.B.1.a.2	Coal Mining and Handling – Surface Mines	CH_4	64.3	0.1	98.4
2.A.4	Mineral Industry – Other Process Uses of Carbonates	CO_2	55.8	0.1	98.4
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing	CO_2	54.3	0.1	98.5
1.A.3.d	Domestic Navigation – Residual Fuel Oil	CO_2	53.5	0.0	98.5
2.C.3	Metal Industry – Aluminium Production	PFCs	50.9	0.0	98.6
1.A.2.d	Pulp, Paper and Print – Liquid Fuels	CO_2	50.7	0.0	98.6
1.A.4.b	Other Sectors – Residential	CH_4	50.0	0.0	98.6
5.B	Waste – Biological Treatment of Solid Waste	CH_4	48.8	0.0	98.7
1.A.4.a	Other Sectors – Commercial/Institutional	CO_2	48.7	0.0	98.7
4.A.1	Forest Land – Forest Land Remaining Forest Land	CH_4	48.4	0.0	98.8
1.A.1.c	Energy Industries – Manufacture of Solid Fuels and Other Energy Industries	CO_2	47.8	0.0	98.8
2.D	Industrial Processes and Product Use – Non-energy Products from Fuels and Solvent Use	CO_2	41.2	0.0	98.9
3.B.1.3	CH_4 Emissions – Swine	CH_4	40.5	0.0	98.9
4.E.2	Settlements – Land Converted to Settlements	CO_2	39.2	0.0	98.9
1.A.3.e	Transport – Other Transportation (please specify)	CO_2	38.0	0.0	99.0

Note: Key categories are those that comprise 95 per cent of the total, as indicated in the shaded and bold cells. Removals from the LULUCF sector are shown as negatives in this table. The absolute values for those removals were 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 2022

CRT category code	IPCC category	Gas	2022 estimate (kt CO_2-equivalent)	Level assessment (%)	Cumulative total (%)
3.A.1	Option A – Dairy Cattle	CH_4	15,992.6	20.4	20.4
1.A.3.b	Transport – Road Transportation	CO_2	12,352.6	15.8	36.2
3.A.2	Other (please specify) – Sheep	CH_4	8,865.5	11.3	47.5
3.A.1	Option A – Non-dairy Cattle	CH_4	7,203.1	9.2	56.7
3.D.1.3	Direct N_2O Emissions from Managed Soils – Urine and Dung Deposited by Grazing Animals	N_2O	3,255.5	4.2	60.8
5.A	Waste – Solid Waste Disposal	CH_4	2,840.6	3.6	64.4
1.A.1.a	Energy Industries – Public Electricity and Heat Production	CO_2	1,977.4	2.5	67.0
2.C.1	Metal Industry – Iron and Steel Production	CO_2	1,541.6	2.0	68.9
3.B.1.1	Cattle – Option A	CH_4	1,541.3	2.0	70.9
2.F.1	Product Uses as Substitutes for ODS – Refrigeration and Air Conditioning	HFCs	1,422.7	1.8	72.7
1.A.2.e	Food Processing, Beverages and Tobacco – Solid Fuels	CO_2	1,365.2	1.7	74.4
1.A.4.b	Other Sectors – Residential	CO_2	1,323.7	1.7	76.1
1.A.2.c	Chemicals – Gaseous Fuels	CO_2	1,255.4	1.6	77.7
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing	CO_2	1,148.7	1.5	79.2
1.A.3.a	Domestic Aviation – Jet Kerosene	CO_2	994.7	1.3	80.5
3.D.1.1	Direct N_2O Emissions from Managed Soils – Inorganic N Fertilisers	N_2O	961.4	1.2	81.7
1.A.2.e	Food Processing, Beverages and Tobacco – Gaseous Fuels	CO_2	947.6	1.2	82.9
1.A.4.a	Other Sectors – Commercial/Institutional	CO_2	852.7	1.1	84.0
3.D.2.1	Indirect N_2O Emissions from Managed Soils – Atmospheric Deposition	N_2O	745.1	1.0	84.9
1.A.1.a	Energy Industries – Public Electricity and Heat Production	CO_2	716.0	0.9	85.9
3.D.1.6	Direct N_2O Emissions from Managed Soils – Cultivation of Organic Soils	N_2O	590.2	0.8	86.6
2.C.3	Metal Industry – Aluminium Production	CO_2	543.9	0.7	87.3
1.A.2.g.v	Other (please specify) – Construction	CO_2	516.2	0.7	88.0
3.A.4	Other Livestock – Deer	CH_4	508.0	0.6	88.6
3.D.2.2	Indirect N_2O Emissions from Managed Soils – Nitrogen Leaching and Run-off	N_2O	479.5	0.6	89.2
3.G	Agriculture – Liming	CO_2	445.6	0.6	89.8
1.B.2.d	Other (please specify) – Geothermal	CO_2	419.5	0.5	90.3
2.A.1	Mineral Industry – Cement Production	CO_2	408.4	0.5	90.8
3.H	Agriculture – Urea Application	CO_2	404.9	0.5	91.4
1.B.2.c.1.ii	Venting – Gas	CO_2	404.9	0.5	91.9
1.A.4.a	Other Sectors – Commercial/Institutional	CO_2	403.6	0.5	92.4
1.A.4.b	Other Sectors – Residential	CO_2	366.5	0.5	92.9
1.A.2.e	Food Processing, Beverages and Tobacco – Liquid Fuels	CO_2	360.3	0.5	93.3
1.A.2.g.iii	Mining (excluding fuels) and Quarrying – Liquid Fuels	CO_2	335.1	0.4	93.7
5.D	Waste – Wastewater Treatment and Discharge	CH_4	287.4	0.4	94.1
3.D.1.4	Direct N_2O Emissions from Managed Soils – Crop Residues	N_2O	225.7	0.3	94.4
1.A.2.g.viii	Other (please specify) – Other (please specify)	CO_2	221.8	0.3	94.7

CRT category code	IPCC category	Gas	2022 estimate (kt CO_2-equivalent)	Level assessment (%)	Cumulative total (%)
1.A.1.c	**Energy Industries – Manufacture of Solid Fuels and Other Energy Industries**	**CO_2**	**195.6**	**0.2**	**94.9**
1.A.2.f	**Non-metallic Minerals – Solid Fuels**	**CO_2**	**187.2**	**0.2**	**95.2**
1.A.1.b	Petroleum Refining – Liquid Fuels	CO_2	162.1	0.2	95.4
1.B.2.b.2	Natural Gas – Production	CH_4	140.2	0.2	95.6
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing	CO_2	139.2	0.2	95.7
1.A.2.d	Pulp, Paper and Print – Gaseous Fuels	CO_2	135.6	0.2	95.9
1.A.2.f	Non-metallic Minerals – Gaseous Fuels	CO_2	123.7	0.2	96.1
1.A.3.c	Railways – Liquid Fuels	CO_2	115.2	0.1	96.2
1.B.2.d	Other (please specify) – Geothermal	CH_4	113.1	0.1	96.4
5.D	Waste – Wastewater Treatment and Discharge	N_2O	107.6	0.1	96.5
1.A.2.a	Iron and Steel – Gaseous Fuels	CO_2	103.2	0.1	96.6
2.A.2	Mineral Industry – Lime Production	CO_2	101.5	0.1	96.8
3.B.1.1	Cattle – Option A	CH_4	99.8	0.1	96.9
3.B.1.2	CH_4 Emissions – Sheep	CH_4	96.9	0.1	97.0
2.G.3	Other Product Manufacture and Use – N_2O from Product Uses	N_2O	94.7	0.1	97.1
3.B.2.5	N_2O and NMVOC Emissions – Indirect N_2O Emissions	N_2O	84.9	0.1	97.2
5.C	Waste – Incineration and Open Burning of Waste	CO_2	83.3	0.1	97.3
5.C	Waste – Incineration and Open Burning of Waste	CH_4	81.9	0.1	97.4
2.B.8	Chemical Industry – Petrochemical and Carbon Black Production	CH_4	78.1	0.1	97.5
1.A.3.b	Transport – Road Transportation	N_2O	72.8	0.1	97.6
1.A.2.g.iii	Mining (excluding fuels) and Quarrying – Solid Fuels	CO_2	71.7	0.1	97.7
1.A.2.f	Non-metallic Minerals – Liquid Fuels	CO_2	68.8	0.1	97.8
2.F.4	Product Uses as Substitutes for ODS – Aerosols	HFCs	67.8	0.1	97.9
3.D.1.2	Direct N_2O Emissions from Managed Soils – Organic N Fertilisers	N_2O	65.0	0.1	98.0
1.B.1.a.2	Coal Mining and Handling – Surface Mines	CH_4	64.3	0.1	98.1
2.A.4	Mineral Industry – Other Process Uses of Carbonates	CO_2	55.8	0.1	98.1
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing	CO_2	54.3	0.1	98.2
1.A.3.d	Domestic Navigation – Residual Fuel Oil	CO_2	53.5	0.1	98.3
2.C.3	Metal Industry – Aluminium Production	PFCs	50.9	0.1	98.3
1.A.2.d	Pulp, Paper and Print – Liquid Fuels	CO_2	50.7	0.1	98.4
1.A.4.b	Other Sectors – Residential	CH_4	50.0	0.1	98.5
5.B	Waste – Biological Treatment of Solid Waste	CH_4	48.8	0.1	98.5
1.A.4.a	Other Sectors – Commercial/Institutional	CO_2	48.7	0.1	98.6
1.A.1.c	Energy Industries – Manufacture of Solid Fuels and Other Energy Industries	CO_2	47.8	0.1	98.7
2.D	Industrial Processes and Product Use – Non-energy Products from Fuels and Solvent Use	CO_2	41.2	0.1	98.7
3.B.1.3	CH_4 Emissions – Swine	CH_4	40.5	0.1	98.8
1.A.3.e	Transport – Other Transportation (please specify)	CO_2	38.0	0.0	98.8
1.A.2.d	Pulp, Paper and Print – Other Fossil Fuels	CO_2	36.6	0.0	98.9
1.B.2.c.1.iii	Venting – Combined	CH_4	34.6	0.0	98.9
1.B.2.b.5	Natural Gas – Distribution	CH_4	34.5	0.0	98.9
1.A.2.g.viii	Other (please specify) – Other (please specify)	CO_2	32.8	0.0	99.0

Note: Key categories are those that comprise 95 per cent of the total, as indicated in the shaded and bold cells.

Table A1.3.2(a) and table A1.3.2(b) present results of the key category level analysis of the net and gross emissions and removals in 1990 respectively. They are included for reference only.

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

CRT category code	IPCC category	Gas	1990 estimate (kt CO_2-equivalent)	Level assessment (%)	Cumulative total (%)
4.A.2	Forest Land – Land Converted to Forest Land	CO_2	-18,085.0	18.7	18.7
3.A.2	Other (please specify) – Sheep	CH_4	16,118.8	16.7	35.4
3.A.1	Option A – Non-dairy Cattle	CH_4	7,359.1	7.6	43.0
3.A.1	Option A – Dairy Cattle	CH_4	6,974.4	7.2	50.3
1.A.3.b	Transport – Road Transportation	CO_2	6,519.0	6.7	57.0
4.A.1	Forest Land – Forest Land Remaining Forest Land	CO_2	-5,434.8	5.6	62.6
5.A	Waste – Solid Waste Disposal	CH_4	3,708.8	3.8	66.5
1.A.1.a	Energy Industries – Public Electricity and Heat Production	CO_2	2,999.6	3.1	69.6
3.D.1.3	Direct N_2O Emissions from Managed Soils – Urine and Dung Deposited by Grazing Animals	N_2O	2,654.1	2.7	72.3
4.G	Land Use, Land-Use Change and Forestry – Harvested Wood Products	CO_2	-2,437.8	2.5	74.8
1.A.1.c	Energy Industries – Manufacture of Solid Fuels and Other Energy Industries	CO_2	1,715.3	1.8	76.6
2.C.1	Metal Industry – Iron and Steel Production	CO_2	1,306.7	1.4	78.0
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing	CO_2	1,071.9	1.1	79.1
1.A.2.e	Food Processing, Beverages and Tobacco – Solid Fuels	CO_2	938.6	1.0	80.1
1.A.3.a	Domestic Aviation – Jet Kerosene	CO_2	892.6	0.9	81.0
2.C.3	Metal Industry – Aluminium Production	PFCs	818.0	0.8	81.8
1.A.4.b	Other Sectors – Residential	CO_2	814.5	0.8	82.7
1.A.1.b	Petroleum Refining – Liquid Fuels	CO_2	778.9	0.8	83.5
1.A.2.g.viii	Other (please specify) – Other (please specify)	CO_2	731.1	0.8	84.2
3.D.2.1	Indirect N_2O Emissions from Managed Soils – Atmospheric Deposition	N_2O	642.7	0.7	84.9
3.D.1.6	Direct N_2O Emissions from Managed Soils – Cultivation of Organic Soils	N_2O	583.1	0.6	85.5
1.A.2.c	Chemicals – Gaseous Fuels	CO_2	524.8	0.5	86.0
1.A.4.a	Other Sectors – Commercial/Institutional	CO_2	500.7	0.5	86.6
4.C.2	Grassland – Land Converted to Grassland	CO_2	484.0	0.5	87.1
3.A.4	Other Livestock – Deer	CH_4	480.8	0.5	87.6
1.A.1.a	Energy Industries – Public Electricity and Heat Production	CO_2	474.8	0.5	88.1
3.B.1.1	Cattle – Option A	CH_4	473.8	0.5	88.5
2.C.3	Metal Industry – Aluminium Production	CO_2	449.0	0.5	89.0
2.A.1	Mineral Industry – Cement Production	CO_2	448.7	0.5	89.5
1.A.2.e	Food Processing, Beverages and Tobacco – Gaseous Fuels	CO_2	443.5	0.5	89.9
3.D.2.2	Indirect N_2O Emissions from Managed Soils – Nitrogen Leaching and Run-off	N_2O	396.1	0.4	90.3
1.A.2.f	Non-metallic Minerals – Solid Fuels	CO_2	382.9	0.4	90.7
4.B.1	Cropland – Cropland Remaining Cropland	CO_2	350.9	0.4	91.1
1.A.2.d	Pulp, Paper and Print – Gaseous Fuels	CO_2	347.6	0.4	91.5
1.A.4.b	Other Sectors – Residential	CO_2	344.9	0.4	91.8

CRT category code	IPCC category	Gas	1990 estimate (kt CO_2-equivalent)	Level assessment (%)	Cumulative total (%)
1.B.1.a.1	**Coal Mining and Handling – Underground Mines**	**CH_4**	**324.3**	**0.3**	**92.2**
1.B.2.b.5	**Natural Gas – Distribution**	**CH_4**	**310.8**	**0.3**	**92.5**
3.G	**Agriculture – Liming**	**CO_2**	**296.5**	**0.3**	**92.8**
1.A.2.e	**Food Processing, Beverages and Tobacco – Liquid Fuels**	**CO_2**	**281.1**	**0.3**	**93.1**
5.D	**Waste – Wastewater Treatment and Discharge**	**CH_4**	**250.9**	**0.3**	**93.3**
1.A.2.g.v	**Other (please specify) – Construction**	**CO_2**	**245.0**	**0.3**	**93.6**
1.A.4.a	**Other Sectors – Commercial/Institutional**	**CO_2**	**235.2**	**0.2**	**93.8**
1.A.3.d	**Domestic Navigation – Residual Fuel Oil**	**CO_2**	**232.9**	**0.2**	**94.1**
1.B.2.d	**Other (please specify) – Geothermal**	**CO_2**	**228.6**	**0.2**	**94.3**
4.C.1	**Grassland – Grassland Remaining Grassland**	**CO_2**	**225.7**	**0.2**	**94.5**
3.A.4	**Other Livestock – Goats**	**CH_4**	**220.2**	**0.2**	**94.8**
3.D.1.1	**Direct N_2O Emissions from Managed Soils – Inorganic N Fertilisers**	**N_2O**	**204.8**	**0.2**	**95.0**
1.A.4.b	Other Sectors – Residential	CO_2	184.9	0.2	95.2
3.B.1.2	CH_4 Emissions – Sheep	CH_4	164.3	0.2	95.3
1.B.2.b.2	Natural Gas – Production	CH_4	160.7	0.2	95.5
3.D.1.4	Direct N_2O Emissions from Managed Soils – Crop Residues	N_2O	156.0	0.2	95.7
5.C	Waste – Incineration and Open Burning of Waste	CO_2	153.6	0.2	95.8
2.B.10	Chemical Industry – Other (please specify)	CO_2	152.3	0.2	96.0
1.A.4.a	Other Sectors – Commercial/Institutional	CO_2	142.2	0.1	96.1
5.C	Waste – Incineration and Open Burning of Waste	CH_4	140.0	0.1	96.3
1.A.3.b	Transport – Road Transportation	CO_2	139.5	0.1	96.4
4.B.2	Cropland – Land Converted to Cropland	CO_2	118.7	0.1	96.5
1.A.2.a	Iron and Steel – Gaseous Fuels	CO_2	116.2	0.1	96.7
1.B.2.c.2.iii	Flaring – Combined	CO_2	114.1	0.1	96.8
4.A.2	Forest Land – Land Converted to Forest Land	N_2O	111.5	0.1	96.9
1.A.2.d	Pulp, Paper and Print – Solid Fuels	CO_2	109.5	0.1	97.0
1.B.2.c.1.ii	Venting – Gas	CO_2	109.3	0.1	97.1
1.B.2.c.1.iii	Venting – Combined	CH_4	109.2	0.1	97.2
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing	CO_2	105.8	0.1	97.4
3.B.1.1	Cattle – Option A	CH_4	101.8	0.1	97.5
1.A.2.g.iii	Mining (excluding fuels) and Quarrying – Liquid Fuels	CO_2	94.4	0.1	97.6
2.G.3	Other Product Manufacture and Use – N_2O from Product Uses	N_2O	88.8	0.1	97.6
2.A.2	Mineral Industry – Lime Production	CO_2	82.6	0.1	97.7
1.A.3.b	Transport – Road Transportation	CH_4	81.7	0.1	97.8
1.A.3.b	Transport – Road Transportation	N_2O	79.4	0.1	97.9
1.A.3.c	Railways – Liquid Fuels	CO_2	78.4	0.1	98.0
5.D	Waste – Wastewater Treatment and Discharge	N_2O	72.9	0.1	98.1
1.B.2.c.2.iii	Flaring – Combined	CH_4	72.4	0.1	98.1
4.A	Forest Land – 4(II) Emissions and Removals from Drainage and Rewetting and Other Management of Organic and Mineral Soils	N_2O	67.0	0.1	98.2
4.E.1	Settlements – Settlements Remaining Settlements	CO_2	66.7	0.1	98.3
3.B.1.3	CH_4 Emissions – Swine	CH_4	65.6	0.1	98.3
1.A.2.f	Non-metallic Minerals – Gaseous Fuels	CO_2	64.1	0.1	98.4

CRT category code	IPCC category	Gas	1990 estimate (kt CO_2-equivalent)	Level assessment (%)	Cumulative total (%)
1.B.2.d	Other (please specify) – Geothermal	CH_4	61.4	0.1	98.5
1.A.2.g.vi	Textile and leather – Gaseous Fuels	CO_2	58.9	0.1	98.5
1.A.4.b	Other Sectors – Residential	CH_4	54.2	0.1	98.6
4.C.1	Grassland – Grassland Remaining Grassland	CH_4	53.4	0.1	98.6
1.A.2.g.viii	Other (please specify) – Other (please specify)	CO_2	52.3	0.1	98.7
1.A.2.d	Pulp, Paper and Print – Liquid Fuels	CO_2	50.1	0.1	98.7
1.A.3.a	Domestic Aviation – Aviation Gasoline	CO_2	47.7	0.0	98.8
3.A.4	Other Livestock – Horses	CH_4	47.4	0.0	98.8
1.A.2.f	Non-metallic Minerals – Liquid Fuels	CO_2	46.0	0.0	98.9
1.B.1.a.2	Coal Mining and Handling – Surface Mines	CH_4	43.1	0.0	98.9
1.A.2.g.i	Manufacturing of Machinery – Gaseous Fuels	CO_2	41.8	0.0	99.0

Note: Key categories are those that comprise 95 per cent of the total, as indicated in the shaded and bold cells. Removals from the LULUCF sector are shown as negatives in this table. The absolute values for those removals were used for the calculations.

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

CRT category code	IPCC category	Gas	1990 estimate (kt CO_2-equivalent)	Level assessment (%)	Cumulative total (%)
3.A.2	**Other (please specify) – Sheep**	**CH_4**	**16,118.8**	**23.4**	**23.4**
3.A.1	**Option A – Non-dairy Cattle**	**CH_4**	**7,359.1**	**10.7**	**34.0**
3.A.1	**Option A – Dairy Cattle**	**CH_4**	**6,974.4**	**10.1**	**44.2**
1.A.3.b	**Transport – Road Transportation**	**CO_2**	**6,519.0**	**9.5**	**53.6**
5.A	**Waste – Solid Waste Disposal**	**CH_4**	**3,708.8**	**5.4**	**59.0**
1.A.1.a	**Energy Industries – Public Electricity and Heat Production**	**CO_2**	**2,999.6**	**4.3**	**63.3**
3.D.1.3	**Direct N_2O Emissions from Managed Soils – Urine and Dung Deposited by Grazing Animals**	**N_2O**	**2,654.1**	**3.8**	**67.2**
1.A.1.c	**Energy Industries – Manufacture of Solid Fuels and Other Energy Industries**	**CO_2**	**1,715.3**	**2.5**	**69.7**
2.C.1	**Metal Industry – Iron and Steel Production**	**CO_2**	**1,306.7**	**1.9**	**71.6**
1.A.4.c	**Other Sectors – Agriculture/Forestry/Fishing**	**CO_2**	**1,071.9**	**1.6**	**73.1**
1.A.2.e	**Food Processing, Beverages and Tobacco – Solid Fuels**	**CO_2**	**938.6**	**1.4**	**74.5**
1.A.3.a	**Domestic Aviation – Jet Kerosene**	**CO_2**	**892.6**	**1.3**	**75.8**
2.C.3	**Metal Industry – Aluminium Production**	**PFCs**	**818.0**	**1.2**	**77.0**
1.A.4.b	**Other Sectors – Residential**	**CO_2**	**814.5**	**1.2**	**78.2**
1.A.1.b	**Petroleum Refining – Liquid Fuels**	**CO_2**	**778.9**	**1.1**	**79.3**
1.A.2.g.viii	**Other (please specify) – Other (please specify)**	**CO_2**	**731.1**	**1.1**	**80.3**
3.D.2.1	**Indirect N_2O Emissions from Managed Soils – Atmospheric Deposition**	**N_2O**	**642.7**	**0.9**	**81.3**
3.D.1.6	**Direct N_2O Emissions from Managed Soils – Cultivation of Organic Soils**	**N_2O**	**583.1**	**0.8**	**82.1**
1.A.2.c	**Chemicals – Gaseous Fuels**	**CO_2**	**524.8**	**0.8**	**82.9**
1.A.4.a	**Other Sectors – Commercial/Institutional**	**CO_2**	**500.7**	**0.7**	**83.6**
3.A.4	**Other Livestock – Deer**	**CH_4**	**480.8**	**0.7**	**84.3**
1.A.1.a	**Energy Industries – Public Electricity and Heat Production**	**CO_2**	**474.8**	**0.7**	**85.0**

CRT category code	IPCC category	Gas	1990 estimate (kt CO_2-equivalent)	Level assessment (%)	Cumulative total (%)
3.B.1.1	**Cattle – Option A**	**CH_4**	**473.8**	**0.7**	**85.7**
2.C.3	**Metal Industry – Aluminium Production**	**CO_2**	**449.0**	**0.7**	**86.3**
2.A.1	**Mineral Industry – Cement Production**	**CO_2**	**448.7**	**0.7**	**87.0**
1.A.2.e	**Food Processing, Beverages and Tobacco – Gaseous Fuels**	**CO_2**	**443.5**	**0.6**	**87.6**
3.D.2.2	**Indirect N_2O Emissions from Managed Soils – Nitrogen Leaching and Run-off**	**N_2O**	**396.1**	**0.6**	**88.2**
1.A.2.f	**Non-metallic Minerals – Solid Fuels**	**CO_2**	**382.9**	**0.6**	**88.8**
1.A.2.d	**Pulp, Paper and Print – Gaseous Fuels**	**CO_2**	**347.6**	**0.5**	**89.3**
1.A.4.b	**Other Sectors – Residential**	**CO_2**	**344.9**	**0.5**	**89.8**
1.B.1.a.1	**Coal Mining and Handling – Underground Mines**	**CH_4**	**324.3**	**0.5**	**90.2**
1.B.2.b.5	**Natural Gas – Distribution**	**CH_4**	**310.8**	**0.5**	**90.7**
3.G	**Agriculture – Liming**	**CO_2**	**296.5**	**0.4**	**91.1**
1.A.2.e	**Food Processing, Beverages and Tobacco – Liquid Fuels**	**CO_2**	**281.1**	**0.4**	**91.5**
5.D	**Waste – Wastewater Treatment and Discharge**	**CH_4**	**250.9**	**0.4**	**91.9**
1.A.2.g.v	**Other (please specify) – Construction**	**CO_2**	**245.0**	**0.4**	**92.2**
1.A.4.a	**Other Sectors – Commercial/Institutional**	**CO_2**	**235.2**	**0.3**	**92.6**
1.A.3.d	**Domestic Navigation – Residual Fuel Oil**	**CO_2**	**232.9**	**0.3**	**92.9**
1.B.2.d	**Other (please specify) – Geothermal**	**CO_2**	**228.6**	**0.3**	**93.2**
3.A.4	**Other Livestock – Goats**	**CH_4**	**220.2**	**0.3**	**93.6**
3.D.1.1	**Direct N_2O Emissions from Managed Soils – Inorganic N Fertilisers**	**N_2O**	**204.8**	**0.3**	**93.9**
1.A.4.b	**Other Sectors – Residential**	**CO_2**	**184.9**	**0.3**	**94.1**
3.B.1.2	**CH_4 Emissions – Sheep**	**CH_4**	**164.3**	**0.2**	**94.4**
1.B.2.b.2	**Natural Gas – Production**	**CH_4**	**160.7**	**0.2**	**94.6**
3.D.1.4	**Direct N_2O Emissions from Managed Soils – Crop Residues**	**N_2O**	**156.0**	**0.2**	**94.8**
5.C	**Waste – Incineration and Open Burning of Waste**	**CO_2**	**153.6**	**0.2**	**95.0**
2.B.10	Chemical Industry – Other (please specify)	CO_2	152.3	0.2	95.3
1.A.4.a	Other Sectors – Commercial/Institutional	CO_2	142.2	0.2	95.5
5.C	Waste – Incineration and Open Burning of Waste	CH_4	140.0	0.2	95.7
1.A.3.b	Transport – Road Transportation	CO_2	139.5	0.2	95.9
1.A.2.a	Iron and Steel – Gaseous Fuels	CO_2	116.2	0.2	96.1
1.B.2.c.2.iii	Flaring – Combined	CO_2	114.1	0.2	96.2
1.A.2.d	Pulp, Paper and Print – Solid Fuels	CO_2	109.5	0.2	96.4
1.B.2.c.1.ii	Venting – Gas	CO_2	109.3	0.2	96.5
1.B.2.c.1.iii	Venting – Combined	CH_4	109.2	0.2	96.7
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing	CO_2	105.8	0.2	96.8
3.B.1.1	Cattle – Option A	CH_4	101.8	0.1	97.0
1.A.2.g.iii	Mining (excluding fuels) and Quarrying – Liquid Fuels	CO_2	94.4	0.1	97.1
2.G.3	Other Product Manufacture and Use – N_2O from Product Uses	N_2O	88.8	0.1	97.3
2.A.2	Mineral Industry – Lime Production	CO_2	82.6	0.1	97.4
1.A.3.b	Transport – Road Transportation	CH_4	81.7	0.1	97.5
1.A.3.b	Transport – Road Transportation	N_2O	79.4	0.1	97.6
1.A.3.c	Railways – Liquid Fuels	CO_2	78.4	0.1	97.7
5.D	Waste – Wastewater Treatment and Discharge	N_2O	72.9	0.1	97.8

CRT category code	IPCC category	Gas	1990 estimate (kt CO_2-equivalent)	Level assessment (%)	Cumulative total (%)
1.B.2.c.2.iii	Flaring – Combined	CH_4	72.4	0.1	97.9
3.B.1.3	CH_4 Emissions – Swine	CH_4	65.6	0.1	98.0
1.A.2.f	Non-metallic Minerals – Gaseous Fuels	CO_2	64.1	0.1	98.1
1.B.2.d	Other (please specify) – Geothermal	CH_4	61.4	0.1	98.2
1.A.2.g.vi	Textile and leather – Gaseous Fuels	CO_2	58.9	0.1	98.3
1.A.4.b	Other Sectors – Residential	CH_4	54.2	0.1	98.4
1.A.2.g.viii	Other (please specify) – Other (please specify)	CO_2	52.3	0.1	98.5
1.A.2.d	Pulp, Paper and Print – Liquid Fuels	CO_2	50.1	0.1	98.5
1.A.3.a	Domestic Aviation – Aviation Gasoline	CO_2	47.7	0.1	98.6
3.A.4	Other Livestock – Horses	CH_4	47.4	0.1	98.7
1.A.2.f	Non-metallic Minerals – Liquid Fuels	CO_2	46.0	0.1	98.7
1.B.1.a.2	Coal Mining and Handling – Surface Mines	CH_4	43.1	0.1	98.8
1.A.2.g.i	Manufacturing of Machinery – Gaseous Fuels	CO_2	41.8	0.1	98.9
3.H	Agriculture – Urea Application	CO_2	39.2	0.1	98.9
1.A.4.c	Other Sectors – Agriculture/Forestry/Fishing	CO_2	35.1	0.1	99.0

Note: Key categories are those that comprise 95 per cent of the total, as indicated in the shaded and bold cells.

Table A1.3.3(a) and table A1.3.3(b) present results of the key category trend analysis of the net and gross emissions and removals in 1990 and 2022 respectively.

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 and 2022

CRT category code	IPCC category	Gas	1990 estimate (kt CO_2-equivalent)	2022 estimate (kt CO_2-equivalent)	Trend assessment	Absolute contribution to trend (%)	Absolute cumulative total (%)
3.A.2	**Other (please specify) – Sheep**	**CH_4**	**16,118.8**	**8,865.5**	**0.129**	**16.2**	**16.2**
4.A.1	**Forest Land – Forest Land Remaining Forest Land**	**CO_2**	**-5,434.8**	**-15,021.1**	**0.118**	**14.7**	**30.8**
4.A.2	**Forest Land – Land Converted to Forest Land**	**CO_2**	**-18,085.0**	**-2,511.4**	**0.100**	**12.5**	**43.4**
3.A.1	**Option A – Dairy Cattle**	**CH_4**	**6,974.4**	**15,992.6**	**0.070**	**8.7**	**52.1**
4.G	**Land Use, Land-Use Change and Forestry – Harvested Wood Products**	**CO_2**	**-2,437.8**	**-6,582.3**	**0.051**	**6.4**	**58.5**
1.A.3.b	**Transport – Road Transportation**	**CO_2**	**6,519.0**	**12,352.6**	**0.038**	**4.8**	**63.3**
3.A.1	**Option A – Non-dairy Cattle**	**CH_4**	**7,359.1**	**7,203.1**	**0.026**	**3.3**	**66.6**
1.A.1.c	**Energy Industries – Manufacture of Solid Fuels and Other Energy Industries**	**CO_2**	**1,715.3**	**195.6**	**0.022**	**2.7**	**69.2**
5.A	**Waste – Solid Waste Disposal**	**CH_4**	**3,708.8**	**2,840.6**	**0.021**	**2.7**	**71.9**
1.A.1.a	**Energy Industries – Public Electricity and Heat Production**	**CO_2**	**2,999.6**	**1,977.4**	**0.021**	**2.6**	**74.5**
4.C.2	**Grassland – Land Converted to Grassland**	**CO_2**	**484.0**	**2,308.4**	**0.017**	**2.2**	**76.7**
2.F.1	**Product Uses as Substitutes for ODS – Refrigeration and Air Conditioning**	**HFCs**	**0.0**	**1,422.7**	**0.015**	**1.8**	**78.5**
2.C.3	**Metal Industry – Aluminium Production**	**PFCs**	**818.0**	**50.9**	**0.011**	**1.3**	**79.8**

CRT category code	IPCC category	Gas	1990 estimate (kt CO_2-equivalent)	2022 estimate (kt CO_2-equivalent)	Trend assessment	Absolute contribution to trend (%)	Absolute cumulative total (%)
4.C.1	Grassland – Grassland Remaining Grassland	CO_2	225.7	1,315.3	0.011	1.3	81.1
1.A.2.g.viii	Other (please specify) – Other (please specify)	CO_2	731.1	32.8	0.010	1.2	82.4
3.B.1.1	Cattle – Option A	CH_4	473.8	1,541.3	0.009	1.2	83.5
1.A.1.b	Petroleum Refining – Liquid Fuels	CO_2	778.9	162.1	0.009	1.1	84.7
3.D.1.1	Direct N_2O Emissions from Managed Soils – Inorganic N Fertilisers	N_2O	204.8	961.4	0.007	0.9	85.6
1.A.2.c	Chemicals – Gaseous Fuels	CO_2	524.8	1,255.4	0.006	0.7	86.3
1.A.4.b	Other Sectors – Residential	CO_2	344.9	13.8	0.005	0.6	86.8
1.B.1.a.1	Coal Mining and Handling – Underground Mines	CH_4	324.3	0.0	0.004	0.6	87.4
1.B.2.b.5	Natural Gas – Distribution	CH_4	310.8	34.5	0.004	0.5	87.9
1.A.2.e	Food Processing, Beverages and Tobacco – Gaseous Fuels	CO_2	443.5	947.6	0.004	0.5	88.4
3.H	Agriculture – Urea Application	CO_2	39.2	404.9	0.004	0.5	88.8
1.A.2.d	Pulp, Paper and Print – Gaseous Fuels	CO_2	347.6	135.6	0.003	0.4	89.2
1.A.2.f	Non-metallic Minerals – Solid Fuels	CO_2	382.9	187.2	0.003	0.4	89.6
1.A.4.c	Other Sectors – Agriculture/ Forestry/Fishing	CO_2	1,071.9	1,148.7	0.003	0.4	90.0
3.A.4	Other Livestock – Goats	CH_4	220.2	22.2	0.003	0.3	90.3
4.B.2	Cropland – Land Converted to Cropland	CO_2	118.7	421.9	0.003	0.3	90.7
3.D.1.3	Direct N_2O Emissions from Managed Soils – Urine and Dung Deposited by Grazing Animals	N_2O	2,654.1	3,255.5	0.003	0.3	91.0
1.B.2.c.1.ii	Venting – Gas	CO_2	109.3	404.9	0.003	0.3	91.4
1.A.3.d	Domestic Navigation – Residual Fuel Oil	CO_2	232.9	53.5	0.003	0.3	91.7
1.A.4.b	Other Sectors – Residential	CO_2	814.5	1,323.7	0.003	0.3	92.0
1.A.2.g.iii	Mining (excluding fuels) and Quarrying – Liquid Fuels	CO_2	94.4	335.1	0.002	0.3	92.3
4.B.1	Cropland – Cropland Remaining Cropland	CO_2	350.9	265.3	0.002	0.3	92.5
1.A.2.g.v	Other (please specify) – Construction	CO_2	245.0	516.2	0.002	0.2	92.8
2.C.1	Metal Industry – Iron and Steel Production	CO_2	1,306.7	1,541.6	0.002	0.2	93.0
1.A.4.a	Other Sectors – Commercial/ Institutional	CO_2	500.7	852.7	0.002	0.2	93.3
1.A.3.a	Domestic Aviation – Jet Kerosene	CO_2	892.6	994.7	0.002	0.2	93.5
2.B.10	Chemical Industry – Other (please specify)	CO_2	152.3	14.4	0.002	0.2	93.8
2.A.1	Mineral Industry – Cement Production	CO_2	448.7	408.4	0.002	0.2	94.0
1.A.3.b	Transport – Road Transportation	CO_2	139.5	0.0	0.002	0.2	94.2

CRT category code	IPCC category	Gas	1990 estimate (kt CO_2-equivalent)	2022 estimate (kt CO_2-equivalent)	Trend assessment	Absolute contribution to trend (%)	Absolute cumulative total (%)
3.D.1.6	**Direct N_2O Emissions from Managed Soils – Cultivation of Organic Soils**	**N_2O**	**583.1**	**590.2**	**0.002**	**0.2**	**94.5**
1.A.2.g.viii	**Other (please specify) – Other (please specify)**	**CO_2**	**52.3**	**221.8**	**0.002**	**0.2**	**94.7**
1.A.4.a	**Other Sectors – Commercial/ Institutional**	**CO_2**	**142.2**	**48.7**	**0.001**	**0.2**	**94.9**
3.A.4	**Other Livestock – Deer**	**CH_4**	**480.8**	**508.0**	**0.001**	**0.2**	**95.0**
1.A.2.d	Pulp, Paper and Print – Solid Fuels	CO_2	109.5	17.9	0.001	0.2	95.2
1.A.4.b	Other Sectors – Residential	CO_2	184.9	366.5	0.001	0.2	95.3
1.A.2.e	Food Processing, Beverages and Tobacco – Solid Fuels	CO_2	938.6	1,365.2	0.001	0.2	95.5
3.B.1.2	CH_4 Emissions – Sheep	CH_4	164.3	96.9	0.001	0.2	95.7
5.C	Waste – Incineration and Open Burning of Waste	CO_2	153.6	83.3	0.001	0.2	95.8
1.B.2.c.2.iii	Flaring – Combined	CO_2	114.1	31.4	0.001	0.2	96.0
1.B.2.d	Other (please specify) – Geothermal	CO_2	228.6	419.5	0.001	0.2	96.1
1.B.2.c.1.iii	Venting – Combined	CH_4	109.2	34.6	0.001	0.1	96.3
3.D.2.1	Indirect N_2O Emissions from Managed Soils – Atmospheric Deposition	N_2O	642.7	745.1	0.001	0.1	96.4
5.C	Waste – Incineration and Open Burning of Waste	CH_4	140.0	81.9	0.001	0.1	96.5
1.A.4.c	Other Sectors – Agriculture/ Forestry/Fishing	CO_2	35.1	139.2	0.001	0.1	96.7
1.A.3.b	Transport – Road Transportation	CH_4	81.7	15.9	0.001	0.1	96.8
1.A.4.a	Other Sectors – Commercial/ Institutional	CO_2	235.2	403.6	0.001	0.1	96.9
1.A.1.a	Energy Industries – Public Electricity and Heat Production	CO_2	474.8	716.0	0.001	0.1	97.0
1.A.4.c	Other Sectors – Agriculture/ Forestry/Fishing	CO_2	105.8	54.3	0.001	0.1	97.1
1.B.2.c.2.iii	Flaring – Combined	CH_4	72.4	10.7	0.001	0.1	97.2
4.A.2	Forest Land – Land Converted to Forest Land	N_2O	111.5	74.9	0.001	0.1	97.3
1.B.2.b.2	Natural Gas – Production	CH_4	160.7	140.2	0.001	0.1	97.4
2.F.4	Product Uses as Substitutes for ODS – Aerosols	HFCs	0.0	67.8	0.001	0.1	97.5
4.F.2	Other Land – Land Converted to Other Land	CO_2	14.6	87.0	0.001	0.1	97.6
4.C.1	Grassland – Grassland Remaining Grassland	CH_4	53.4	11.7	0.001	0.1	97.7
1.A.2.g.vi	Textile and Leather – Gaseous Fuels	CO_2	58.9	20.4	0.001	0.1	97.7
1.A.2.g.iii	Mining (excluding fuels) and Quarrying – Solid Fuels	CO_2	12.2	71.7	0.001	0.1	97.8
3.G	Agriculture – Liming	CO_2	296.5	445.6	0.001	0.1	97.9
2.C.3	Metal Industry – Aluminium Production	CO_2	449.0	543.9	0.001	0.1	97.9
1.A.2.a	Iron and Steel – Gaseous Fuels	CO_2	116.2	103.2	0.001	0.1	98.0

CRT category code	IPCC category	Gas	1990 estimate (kt CO_2-equivalent)	2022 estimate (kt CO_2-equivalent)	Trend assessment	Absolute contribution to trend (%)	Absolute cumulative total (%)
1.A.1.c	Energy Industries – Manufacture of Solid Fuels and Other Energy Industries	CO_2	0.0	47.8	0.000	0.1	98.1
3.B.1.3	CH_4 Emissions – Swine	CH_4	65.6	40.5	0.000	0.1	98.1
3.A.4	Other Livestock – Horses	CH_4	47.4	16.9	0.000	0.1	98.2
3.D.2.2	Indirect N_2O Emissions from Managed Soils – Nitrogen Leaching and Run-off	N_2O	396.1	479.5	0.000	0.1	98.3
5.D	Waste – Wastewater Treatment and Discharge	CH_4	250.9	287.4	0.000	0.1	98.3
5.B	Waste – Biological Treatment of Solid Waste	CH_4	3.1	48.8	0.000	0.1	98.4
3.B.2.5	N_2O and NMVOC Emissions – Indirect N_2O Emissions	N_2O	30.6	84.9	0.000	0.1	98.4
1.A.3.a	Domestic Aviation – Aviation Gasoline	CO_2	47.7	21.1	0.000	0.1	98.5
1.A.2.g.i	Manufacturing of Machinery – Gaseous Fuels	CO_2	41.8	13.6	0.000	0.1	98.5
1.A.4.b	Other Sectors – Residential	CH_4	30.6	1.2	0.000	0.1	98.6
1.A.2.f	Non-metallic Minerals – Gaseous Fuels	CO_2	64.1	123.7	0.000	0.1	98.6
2.B.8	Chemical Industry – Petrochemical and Carbon Black Production	CH_4	30.9	78.1	0.000	0.0	98.7
1.A.2.d	Pulp, Paper and Print – Other Fossil Fuels	CO_2	0.0	36.6	0.000	0.0	98.7
3.B.1.1	Cattle – Option A	CH_4	101.8	99.8	0.000	0.0	98.8
1.A.3.b	Transport – Road Transportation	N_2O	79.4	72.8	0.000	0.0	98.8
1.B.2.d	Other (please specify) – Geothermal	CH_4	61.4	113.1	0.000	0.0	98.9
1.A.3.e	Transport – Other Transportation (please specify)	CO_2	5.5	38.0	0.000	0.0	98.9
4.C.2	Grassland – Land Converted to Grassland	N_2O	27.9	6.3	0.000	0.0	98.9
4.C.1	Grassland – Grassland Remaining Grassland	N_2O	31.6	13.5	0.000	0.0	99.0

Note: Key categories are those that comprise 95 per cent of the total, as indicated in the shaded and bold cells. Removals from the LULUCF sector are shown as negatives in this table. The absolute values for those removals were used for the calculations.

Table A1.3.3(b) Results of the key category trend analysis for 99 per cent of the gross emissions and removals for New Zealand in 1990 and 2022

CRT category code	IPCC category	Gas	1990 estimate (kt CO_2-equivalent)	2022 estimate (kt CO_2-equivalent)	Trend assessment	Absolute contribution to trend (%)	Absolute cumulative total (%)
3.A.2	Other (please specify) – Sheep	CH_4	16,118.8	8,865.5	0.137	21.9	21.9
3.A.1	Option A – Dairy Cattle	CH_4	6,974.4	15,992.6	0.117	18.6	40.5
1.A.3.b	Transport – Road Transportation	CO_2	6,519.0	12,352.6	0.072	11.4	51.9
1.A.1.c	Energy Industries – Manufacture of Solid Fuels and Other Energy Industries	CO_2	1,715.3	195.6	0.025	4.1	55.9
1.A.1.a	Energy Industries – Public Electricity and Heat Production	CO_2	2,999.6	1,977.4	0.021	3.3	59.3
2.F.1	Product Uses as Substitutes for ODS – Refrigeration and Air Conditioning	HFCs	0.0	1,422.7	0.021	3.3	62.5
5.A	Waste – Solid Waste Disposal	CH_4	3,708.8	2,840.6	0.020	3.2	65.7
3.A.1	Option A – Non-dairy Cattle	CH_4	7,359.1	7,203.1	0.017	2.7	68.4
3.B.1.1	Cattle – Option A	CH_4	473.8	1,541.3	0.015	2.3	70.7
2.C.3	Metal Industry – Aluminium Production	PFCs	818.0	50.9	0.013	2.0	72.8
1.A.2.g.viii	Other (please specify) – Other (please specify)	CO_2	731.1	32.8	0.012	1.8	74.6
3.D.1.1	Direct N_2O Emissions from Managed Soils – Inorganic N Fertilisers	N_2O	204.8	961.4	0.011	1.7	76.3
1.A.1.b	Petroleum Refining – Liquid Fuels	CO_2	778.9	162.1	0.010	1.7	78.0
1.A.2.c	Chemicals – Gaseous Fuels	CO_2	524.8	1,255.4	0.010	1.5	79.5
1.A.2.e	Food Processing, Beverages and Tobacco – Gaseous Fuels	CO_2	443.5	947.6	0.006	1.0	80.5
1.A.4.b	Other Sectors – Residential	CO_2	814.5	1,323.7	0.006	0.9	81.4
1.A.4.b	Other Sectors – Residential	CO_2	344.9	13.8	0.005	0.9	82.3
1.B.1.a.1	Coal Mining and Handling – Underground Mines	CH_4	324.3	0.0	0.005	0.9	83.1
3.H	Agriculture – Urea Application	CO_2	39.2	404.9	0.005	0.8	84.0
1.B.2.b.5	Natural Gas – Distribution	CH_4	310.8	34.5	0.005	0.7	84.7
1.A.2.e	Food Processing, Beverages and Tobacco – Solid Fuels	CO_2	938.6	1,365.2	0.004	0.7	85.4
1.A.4.a	Other Sectors – Commercial/ Institutional	CO_2	500.7	852.7	0.004	0.7	86.1
1.B.2.c.1.ii	Venting – Gas	CO_2	109.3	404.9	0.004	0.6	86.7
1.A.2.d	Pulp, Paper and Print – Gaseous Fuels	CO_2	347.6	135.6	0.004	0.6	87.3
1.A.2.f	Non-metallic Minerals – Solid Fuels	CO_2	382.9	187.2	0.004	0.6	87.9
3.D.1.3	Direct N_2O Emissions from Managed Soils – Urine and Dung Deposited by Grazing Animals	N_2O	2,654.1	3,255.5	0.003	0.6	88.4
1.A.2.g.v	Other (please specify) – Construction	CO_2	245.0	516.2	0.003	0.5	89.0
3.A.4	Other Livestock – Goats	CH_4	220.2	22.2	0.003	0.5	89.5
1.A.2.g.iii	Mining (excluding fuels) and Quarrying – Liquid Fuels	CO_2	94.4	335.1	0.003	0.5	90.0

CRT category code	IPCC category	Gas	1990 estimate (kt CO_2-equivalent)	2022 estimate (kt CO_2-equivalent)	Trend assessment	Absolute contribution to trend (%)	Absolute cumulative total (%)
1.A.3.d	**Domestic Navigation – Residual Fuel Oil**	**CO_2**	**232.9**	**53.5**	**0.003**	**0.5**	**90.5**
1.A.1.a	**Energy Industries – Public Electricity and Heat Production**	**CO_2**	**474.8**	**716.0**	**0.003**	**0.4**	**90.9**
1.A.2.g.viii	**Other (please specify) – Other (please specify)**	**CO_2**	**52.3**	**221.8**	**0.002**	**0.4**	**91.3**
1.B.2.d	**Other (please specify) – Geothermal**	**CO_2**	**228.6**	**419.5**	**0.002**	**0.4**	**91.7**
2.B.10	**Chemical Industry – Other (please specify)**	**CO_2**	**152.3**	**14.4**	**0.002**	**0.4**	**92.0**
1.A.3.b	**Transport – Road Transportation**	**CO_2**	**139.5**	**0.0**	**0.002**	**0.4**	**92.4**
1.A.4.b	**Other Sectors – Residential**	**CO_2**	**184.9**	**366.5**	**0.002**	**0.4**	**92.8**
1.A.4.a	**Other Sectors – Commercial/ Institutional**	**CO_2**	**235.2**	**403.6**	**0.002**	**0.3**	**93.1**
1.A.4.a	**Other Sectors – Commercial/ Institutional**	**CO_2**	**142.2**	**48.7**	**0.002**	**0.3**	**93.3**
3.G	**Agriculture – Liming**	**CO_2**	**296.5**	**445.6**	**0.002**	**0.3**	**93.6**
1.A.2.d	**Pulp, Paper and Print – Solid Fuels**	**CO_2**	**109.5**	**17.9**	**0.002**	**0.2**	**93.8**
2.A.1	**Mineral Industry – Cement Production**	**CO_2**	**448.7**	**408.4**	**0.001**	**0.2**	**94.1**
1.A.4.c	**Other Sectors – Agriculture/ Forestry/Fishing**	**CO_2**	**35.1**	**139.2**	**0.001**	**0.2**	**94.3**
1.B.2.c.2.iii	**Flaring – Combined**	**CO_2**	**114.1**	**31.4**	**0.001**	**0.2**	**94.5**
5.C	**Waste – Incineration and Open Burning of Waste**	**CO_2**	**153.6**	**83.3**	**0.001**	**0.2**	**94.7**
3.B.1.2	**CH_4 Emissions – Sheep**	**CH_4**	**164.3**	**96.9**	**0.001**	**0.2**	**94.9**
1.B.2.c.1.iii	**Venting – Combined**	**CH_4**	**109.2**	**34.6**	**0.001**	**0.2**	**95.2**
5.C	Waste – Incineration and Open Burning of Waste	CH_4	140.0	81.9	0.001	0.2	95.3
1.A.3.b	Transport – Road Transportation	CH_4	81.7	15.9	0.001	0.2	95.5
3.D.1.6	Direct N_2O Emissions from Managed Soils – Cultivation of Organic Soils	N_2O	583.1	590.2	0.001	0.2	95.7
1.B.2.c.2.iii	Flaring – Combined	CH_4	72.4	10.7	0.001	0.2	95.8
1.A.4.c	Other Sectors – Agriculture/ Forestry/Fishing	CO_2	1,071.9	1,148.7	0.001	0.2	96.0
2.F.4	Product Uses as Substitutes for ODS – Aerosols	HFCs	0.0	67.8	0.001	0.2	96.2
1.A.4.c	Other Sectors – Agriculture/ Forestry/Fishing	CO_2	105.8	54.3	0.001	0.2	96.3
1.A.2.g.iii	Mining (excluding fuels) and Quarrying – Solid Fuels	CO_2	12.2	71.7	0.001	0.1	96.4
2.C.1	Metal Industry – Iron and Steel Production	CO_2	1,306.7	1,541.6	0.001	0.1	96.6
1.A.2.f	Non-metallic Minerals – Gaseous Fuels	CO_2	64.1	123.7	0.001	0.1	96.7
3.B.2.5	N_2O and NMVOC Emissions – Indirect N_2O Emissions	N_2O	30.6	84.9	0.001	0.1	96.8
3.D.1.4	Direct N_2O Emissions from Managed Soils – Crop Residues	N_2O	156.0	225.7	0.001	0.1	96.9

CRT category code	IPCC category	Gas	1990 estimate (kt CO_2-equivalent)	2022 estimate (kt CO_2-equivalent)	Trend assessment	Absolute contribution to trend (%)	Absolute cumulative total (%)
1.A.1.c	Energy Industries – Manufacture of Solid Fuels and Other Energy Industries	CO_2	0.0	47.8	0.001	0.1	97.0
1.A.2.g.vi	Textile and Leather – Gaseous Fuels	CO_2	58.9	20.4	0.001	0.1	97.1
5.B	Waste – Biological Treatment of Solid Waste	CH_4	3.1	48.8	0.001	0.1	97.2
1.B.2.d	Other (please specify) – Geothermal	CH_4	61.4	113.1	0.001	0.1	97.3
2.B.8	Chemical Industry – Petrochemical and Carbon Black Production	CH_4	30.9	78.1	0.001	0.1	97.4
1.B.2.b.2	Natural Gas – Production	CH_4	160.7	140.2	0.001	0.1	97.5
1.A.2.e	Food Processing, Beverages and Tobacco – Liquid Fuels	CO_2	281.1	360.3	0.001	0.1	97.6
3.A.4	Other Livestock – Deer	CH_4	480.8	508.0	0.001	0.1	97.7
3.A.4	Other Livestock – Horses	CH_4	47.4	16.9	0.001	0.1	97.8
1.A.2.d	Pulp, Paper and Print – Other Fossil Fuels	CO_2	0.0	36.6	0.001	0.1	97.9
3.B.1.3	CH_4 Emissions – Swine	CH_4	65.6	40.5	0.000	0.1	98.0
1.A.2.g.i	Manufacturing of Machinery – Gaseous Fuels	CO_2	41.8	13.6	0.000	0.1	98.1
1.A.4.b	Other Sectors – Residential	CH_4	30.6	1.2	0.000	0.1	98.1
2.C.3	Metal Industry – Aluminium Production	CO_2	449.0	543.9	0.000	0.1	98.2
1.A.3.a	Domestic Aviation – Aviation Gasoline	CO_2	47.7	21.1	0.000	0.1	98.3
1.A.3.e	Transport – Other Transportation (please specify)	CO_2	5.5	38.0	0.000	0.1	98.4
3.D.2.2	Indirect N_2O Emissions from Managed Soils – Nitrogen Leaching and Run-off	N_2O	396.1	479.5	0.000	0.1	98.4
1.A.2.a	Iron and Steel – Gaseous Fuels	CO_2	116.2	103.2	0.000	0.1	98.5
3.D.1.2	Direct N_2O Emissions from Managed Soils – Organic N Fertilisers	N_2O	32.1	65.0	0.000	0.1	98.6
1.B.2.b.4	Natural Gas – Transmission and Storage	CH_4	2.8	30.9	0.000	0.1	98.6
1.A.3.c	Railways – Liquid Fuels	CO_2	78.4	115.2	0.000	0.1	98.7
5.B	Waste – Biological Treatment of Solid Waste	N_2O	1.7	27.7	0.000	0.1	98.7
5.D	Waste – Wastewater Treatment and Discharge	N_2O	72.9	107.6	0.000	0.1	98.8
1.A.2.b	Non-Ferrous Metals – Solid Fuels	CO_2	0.0	22.0	0.000	0.1	98.8
2.A.4	Mineral Industry – Other Process Uses of Carbonates	CO_2	30.5	55.8	0.000	0.0	98.9
1.A.3.a	Domestic Aviation – Jet Kerosene	CO_2	892.6	994.7	0.000	0.0	98.9
1.A.4.a	Other Sectors – Commercial/ Institutional	CO_2	0.0	19.9	0.000	0.0	99.0

Note: Key categories are those that comprise 95 per cent of the total, as indicated in the shaded and bold cells.

Annex 1: Reference

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 and guides decisions on methodological choice.

New Zealand has followed the Approach 1 methodology for uncertainty analysis, in line with the Intergovernmental Panel on Climate Change (IPCC) methodological guidelines (IPCC, 2006). In this method, uncertainties for individual categories of emissions are combined 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 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. 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.

Type A sensitivity: the change in the difference in overall emissions between the base year and the current year, expressed as a percentage, resulting from a 1 per cent increase in emissions or removals of a given category and gas in both the base year and the current year.

Type B sensitivity: the change in the difference in overall emissions between the base year and the current year, expressed as a percentage, resulting from a 1 per cent increase in emissions or removals of a given category and gas in the current year only.

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

Table A2.1.1 Uncertainty calculation of the net emissions and removals for New Zealand in 2022

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO_2-e)	2022 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 2022 (%)	Type A sensitivity (%)	Type B sensitivity (%)	Uncertainty in the trend in national total introduced by emission or removal factor uncertainty (%)	Uncertainty in the 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 2022
Energy – Gaseous Fuels	CO_2	7,026.45	5,710.19	3.5	2.4	4.2	0.6687	0.4100	0.0806	0.1279	0.1942	0.6329	0.6620	0.4472	0.1681
Energy – Liquid Fuels	CO_2	11,789.48	18,676.48	0.7	0.5	0.9	0.2305	0.2755	0.0682	0.4184	0.0341	0.4233	0.4246	0.0531	0.0759
Energy – Other Fossil Fuels	CO_2	0.02	64.96	5.0	5.0	7.1	0.0000	0.0078	0.0015	0.0015	0.0073	0.0103	0.0126	0.0000	0.0001
Energy – Solid Fuels	CO_2	3,211.03	2,632.49	15.2	2.2	15.4	1.1063	0.6843	0.0363	0.0590	0.0790	1.2698	1.2722	1.2239	0.4683
Energy – Fugitive – Oil Exploration	CO_2	0.00	0.00	0.7	100.0	100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Energy – Fugitive – Oil Production	CO_2	0.00	0.00	0.7	100.0	100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Energy – Fugitive – Oil Transport	CO_2	0.01	0.00	0.7	100.0	100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Energy – Fugitive – Gas Production	CO_2	0.21	0.18	3.5	100.0	100.1	0.0005	0.0003	0.0000	0.0000	0.0002	0.0000	0.0002	0.0000	0.0000
Energy – Fugitive – Gas Transmission and Storage	CO_2	0.01	0.27	3.5	100.0	100.1	0.0000	0.0005	0.0000	0.0000	0.0006	0.0000	0.0006	0.0000	0.0000
Energy – Fugitive – Gas Distribution	CO_2	1.45	0.30	3.5	100.0	100.1	0.0032	0.0005	0.0000	0.0000	0.0036	0.0000	0.0036	0.0000	0.0000
Energy – Fugitive – Venting and Flaring	CO_2	229.48	441.43	3.5	2.4	4.2	0.0218	0.0317	0.0031	0.0099	0.0074	0.0489	0.0495	0.0005	0.0010
Energy – Fugitive – Other Forms of Energy Production	CO_2	228.58	419.45	5.0	5.0	7.1	0.0362	0.0501	0.0026	0.0094	0.0131	0.0665	0.0677	0.0013	0.0025
2.A.1 Cement Production	CO_2	448.75	408.36	1.0	1.0	1.4	0.0142	0.0098	0.0042	0.0091	0.0042	0.0129	0.0136	0.0002	0.0001
2.A.2 Lime Production	CO_2	82.60	101.48	2.0	2.0	2.8	0.0052	0.0049	0.0002	0.0023	0.0004	0.0064	0.0064	0.0000	0.0000
2.A.4.a Ceramics	CO_2	0.01	0.01	50.0	20.0	53.9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.A.4.b Other Uses of Soda Ash	CO_2	5.87	7.08	3.0	2.0	3.6	0.0005	0.0004	0.0000	0.0002	0.0000	0.0007	0.0007	0.0000	0.0000
2.A.4.d Other – Other Uses of Limestone	CO_2	24.63	48.68	3.0	2.0	3.6	0.0020	0.0030	0.0004	0.0011	0.0007	0.0046	0.0047	0.0000	0.0000
2.B.1 Ammonia Production	CO_2	21.68	19.54	2.0	6.0	6.3	0.0031	0.0021	0.0002	0.0004	0.0012	0.0012	0.0018	0.0000	0.0000
2.B.5.b Calcium Carbide	CO_2	1.43	1.43	50.0	50.0	70.7	0.0023	0.0017	0.0000	0.0000	0.0005	0.0023	0.0023	0.0000	0.0000
2.B.10 Hydrogen Production	CO_2	152.29	14.38	2.0	6.0	6.3	0.0216	0.0015	0.0042	0.0003	0.0252	0.0009	0.0252	0.0005	0.0000
2.C.1 Iron and steel	CO_2	1,306.73	1,541.56	5.0	7.0	8.6	0.2518	0.2242	0.0043	0.0345	0.0298	0.2442	0.2460	0.0634	0.0503

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO_2-e)	2022 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 2022 (%)	Type A sensitivity (%)	Type B sensitivity (%)	Uncertainty in the trend in national total introduced by emission or removal factor uncertainty (%)	Uncertainty in the 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 2022
2.C.3.a Aluminium	CO_2	448.98	543.93	5.0	2.0	5.4	0.0542	0.0495	0.0011	0.0122	0.0023	0.0862	0.0862	0.0029	0.0025
2.C.5 Secondary Lead Production	CO_2	1.80	0.00	50.0	50.0	70.7	0.0029	0.0000	0.0001	0.0000	0.0027	0.0000	0.0027	0.0000	0.0000
2.D.1 Lubricant Use	CO_2	22.83	34.68	20.0	50.0	53.9	0.0275	0.0316	0.0001	0.0008	0.0050	0.0220	0.0225	0.0008	0.0010
2.D.2 Paraffin Wax	CO_2	2.35	2.35	20.0	100.0	102.0	0.0054	0.0040	0.0000	0.0001	0.0017	0.0015	0.0023	0.0000	0.0000
2.D.3 Other: Urea Catalyst in Road Transport	CO_2	0.00	4.21	50.0	10.0	51.0	0.0000	0.0036	0.0001	0.0001	0.0009	0.0067	0.0067	0.0000	0.0000
Agriculture – Liming	CO_2	296.48	445.62	3.4	50.0	50.1	0.3329	0.3775	0.0012	0.0100	0.0590	0.0480	0.0761	0.1108	0.1425
Agriculture – Urea Application	CO_2	39.19	404.93	10.0	50.0	51.0	0.0448	0.3490	0.0079	0.0091	0.3954	0.1283	0.4157	0.0020	0.1218
LULUCF – Forest Land	CO_2	-23,519.79	-17,532.51	0.0	66.9	66.9	-35.2273	-19.8129	0.3072	0.3928	20.5382	0.0000	20.5382	1,240.9645	392.5524
LULUCF – Cropland	CO_2	469.54	687.26	0.0	59.7	59.7	0.6283	0.6939	0.0015	0.0154	0.0869	0.0000	0.0869	0.3948	0.4815
LULUCF – Grassland	CO_2	709.75	3,623.71	0.0	33.3	33.3	0.5295	2.0397	0.0601	0.0812	2.0013	0.0000	2.0013	0.2804	4.1604
LULUCF – Wetlands	CO_2	-8.29	7.89	0.0	127.7	127.7	-0.0237	0.0170	0.0004	0.0002	0.0540	0.0000	0.0540	0.0006	0.0003
LULUCF – Settlements	CO_2	78.90	118.04	0.0	65.5	65.5	0.1158	0.1307	0.0003	0.0026	0.0198	0.0000	0.0198	0.0134	0.0171
LULUCF – Other Land	CO_2	14.65	87.00	0.0	85.2	85.2	0.0280	0.1254	0.0015	0.0019	0.1291	0.0000	0.1291	0.0008	0.0157
LULUCF – Harvested Wood Products	CO_2	-2,437.78	-6,582.33	0.0	68.2	68.2	-3.7270	-7.5929	0.0751	0.1475	5.1265	0.0000	5.1265	13.8908	57.6518
Waste – Incineration and Open Burning of Waste	CO_2	153.59	83.33	50.0	40.0	64.0	0.2203	0.0902	0.0027	0.0019	0.1077	0.1320	0.1704	0.0485	0.0081
Tokelau Energy industries – Sectoral Approach – liquid	CO_2	0.23	1.33	10.0	7.0	12.2	0.0001	0.0003	0.0000	0.0000	0.0002	0.0004	0.0005	0.0000	0.0000
Tokelau Gas Diesel Oil – Sectoral Approach – Liquid	CO_2	0.90	1.31	50.0	1.5	50.0	0.0010	0.0011	0.0000	0.0000	0.0000	0.0021	0.0021	0.0000	0.0000
Tokelau Other/ Residential – Sectoral Approach – Liquid	CO_2	0.12	0.10	20.0	7.0	21.2	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000
Tokelau Waste – Incineration and Open Burning of Waste	CO_2	0.05	0.04	50.0	40.0	64.0	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000
Energy – Gaseous Fuels	CH_4	10.14	4.19	3.5	50.0	50.1	0.0114	0.0036	0.0002	0.0001	0.0104	0.0005	0.0104	0.0001	0.0000
Energy – Liquid Fuels	CH_4	98.02	38.81	0.7	50.0	50.0	0.1098	0.0328	0.0020	0.0009	0.1021	0.0009	0.1021	0.0121	0.0011

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO_2-e)	2022 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 2022 (%)	Type A sensitivity (%)	Type B sensitivity (%)	Uncertainty in the trend in national total introduced by emission or removal factor uncertainty (%)	Uncertainty in the 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 2022
Energy – Other Fossil Fuels	CH_4	0.01	0.07	5.0	50.0	50.2	0.0000	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000
Energy – Solid Fuels	CH_4	40.71	18.38	15.2	50.0	52.3	0.0477	0.0162	0.0008	0.0004	0.0398	0.0089	0.0408	0.0023	0.0003
Energy – Biomass	CH_4	77.76	70.68	50.0	50.0	70.7	0.1232	0.0845	0.0007	0.0016	0.0363	0.1120	0.1177	0.0152	0.0071
Energy – Fugitive – Coal Handling	CH_4	367.40	64.32	15.2	50.0	52.3	0.4302	0.0568	0.0095	0.0014	0.4734	0.0310	0.4744	0.1851	0.0032
Energy – Fugitive – Oil Exploration	CH_4	0.00	0.00	0.7	50.0	50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Energy – Fugitive – Oil Production	CH_4	0.07	0.02	0.7	50.0	50.0	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000
Energy – Fugitive – Oil Transport	CH_4	1.88	0.80	0.7	50.0	50.0	0.0021	0.0007	0.0000	0.0000	0.0019	0.0000	0.0019	0.0000	0.0000
Energy – Fugitive – Oil Refining	CH_4	3.06	0.69	0.7	50.0	50.0	0.0034	0.0006	0.0001	0.0000	0.0038	0.0000	0.0038	0.0000	0.0000
Energy – Fugitive – Gas Production	CH_4	160.67	140.24	3.5	50.0	50.1	0.1804	0.1188	0.0016	0.0031	0.0814	0.0155	0.0829	0.0326	0.0141
Energy – Fugitive – Gas Transmission and Storage	CH_4	2.77	30.90	3.5	100.0	100.1	0.0062	0.0523	0.0006	0.0007	0.0610	0.0034	0.0611	0.0000	0.0027
Energy – Fugitive – Gas Distribution	CH_4	310.78	34.47	3.5	100.0	100.1	0.6967	0.0583	0.0085	0.0008	0.8456	0.0038	0.8456	0.4854	0.0034
Energy – Fugitive – Venting and Flaring	CH_4	181.62	45.27	3.5	50.0	50.1	0.2040	0.0384	0.0044	0.0010	0.2189	0.0050	0.2190	0.0416	0.0015
Energy – Fugitive – Other Forms of Energy Production	CH_4	61.37	113.13	5.0	50.0	50.2	0.0691	0.0961	0.0007	0.0025	0.0356	0.0179	0.0399	0.0048	0.0092
2.B.8 Methanol	CH_4	30.91	78.12	2.0	80.0	80.0	0.0554	0.1057	0.0008	0.0018	0.0666	0.0050	0.0668	0.0031	0.0112
Agriculture – Enteric Fermentation	CH_4	31,212.52	32,617.20	3.9	15.5	16.0	11.1889	8.8219	0.1947	0.7308	3.0214	4.0306	5.0373	125.1915	77.8265
Agriculture – Manure Management	CH_4	829.90	1,803.70	5.0	20.0	20.6	0.3833	0.6286	0.0158	0.0404	0.3153	0.2858	0.4255	0.1469	0.3951
Agriculture – Burning of Residues	CH_4	25.34	17.94	6.0	20.0	20.9	0.0119	0.0063	0.0004	0.0004	0.0070	0.0034	0.0078	0.0001	0.0000
CH_4 Emissions Associated with Biomass Burning (CO_2-e)	CH_4	76.56	82.29	30.0	41.7	51.4	0.0882	0.0715	0.0004	0.0018	0.0179	0.0782	0.0803	0.0078	0.0051
Waste – Solid Waste Disposal	CH_4	3,708.78	2,840.62	86.3	40.0	95.1	7.9047	4.5680	0.0464	0.0636	1.8580	7.7685	7.9876	62.4844	20.8666
Waste – Wastewater Treatment and Discharge	CH_4	250.92	287.40	10.0	40.0	41.2	0.2318	0.2003	0.0010	0.0064	0.0405	0.0911	0.0997	0.0537	0.0401

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO_2-e)	2022 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 2022 (%)	Type A sensitivity (%)	Type B sensitivity (%)	Uncertainty in the trend in national total introduced by emission or removal factor uncertainty (%)	Uncertainty in the 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 2022
Waste – Biological Treatment of Solid Waste	CH_4	3.07	48.81	100.0	100.0	141.4	0.0097	0.1167	0.0010	0.0011	0.1002	0.1546	0.1843	0.0001	0.0136
Waste – Incineration and Open Burning of Waste	CH_4	139.99	81.88	50.0	100.0	111.8	0.3507	0.1547	0.0023	0.0018	0.2322	0.1297	0.2660	0.1230	0.0239
Tokelau Energy Industries – Sectoral Approach – Liquid	CH_4	0.00	0.00	10.0	50.0	51.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tokelau Gas Diesel Oil – Sectoral Approach – Liquid	CH_4	0.00	0.00	50.0	50.0	70.7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tokelau Other/ Residential – Sectoral Approach – Liquid	CH_4	0.00	0.00	20.0	50.0	53.9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tokelau Agriculture – Enteric Fermentation	CH_4	0.10	0.07	20.0	50.0	53.9	0.0001	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000
Tokelau Agriculture – Manure Management	CH_4	1.19	0.85	20.0	30.0	36.1	0.0010	0.0005	0.0000	0.0000	0.0005	0.0005	0.0007	0.0000	0.0000
Tokelau Waste – Solid Waste Disposal	CH_4	0.44	0.35	140.0	40.0	145.6	0.0014	0.0009	0.0000	0.0000	0.0002	0.0015	0.0015	0.0000	0.0000
Tokelau Waste – Wastewater Treatment and Discharge	CH_4	0.17	0.30	10.0	40.0	41.2	0.0002	0.0002	0.0000	0.0000	0.0001	0.0001	0.0001	0.0000	0.0000
Tokelau Waste – Incineration and Open Burning of Waste	CH_4	0.10	0.08	50.0	100.0	111.8	0.0002	0.0002	0.0000	0.0000	0.0001	0.0001	0.0002	0.0000	0.0000
Energy – Gaseous Fuels	N_2O	4.92	2.61	3.5	50.0	50.1	0.0055	0.0022	0.0001	0.0001	0.0044	0.0003	0.0044	0.0000	0.0000
Energy – Liquid Fuels	N_2O	140.43	158.91	0.7	50.0	50.0	0.1573	0.1343	0.0006	0.0036	0.0305	0.0036	0.0307	0.0248	0.0180
Energy – Other Fossil Fuels	N_2O	0.18	0.13	5.0	50.0	50.2	0.0002	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000
Energy – Solid Fuels	N_2O	13.25	10.49	15.2	50.0	52.3	0.0155	0.0093	0.0002	0.0002	0.0079	0.0051	0.0094	0.0002	0.0001
Energy – Biomass	N_2O	36.54	36.21	50.0	50.0	70.7	0.0579	0.0433	0.0003	0.0008	0.0137	0.0574	0.0590	0.0034	0.0019
Energy – Fugitive – Venting and Flaring	N_2O	0.05	0.02	3.5	100.0	100.1	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000
2.G.3 N_2O from Product Uses	N_2O	88.76	94.74	15.0	0.0	15.0	0.0298	0.0240	0.0005	0.0021	0.0000	0.0450	0.0450	0.0009	0.0006

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Agriculture – Agricultural Soils	N_2O	4,668.99	6,322.49	14.3	54.2	56.1	5.8637	5.9910	0.0030	0.1417	0.1629	2.8647	2.8693	34.3833	35.8917
Agriculture – Manure Management	N_2O	44.86	97.86	5.0	100.0	100.1	0.1006	0.1656	0.0009	0.0022	0.0861	0.0155	0.0874	0.0101	0.0274
Agriculture – Burning of Residues	N_2O	4.24	2.95	6.0	20.0	20.9	0.0020	0.0010	0.0001	0.0001	0.0012	0.0006	0.0013	0.0000	0.0000
Direct and Indirect N_2O Emissions (CO_2-e)	N_2O	269.05	226.19	0.0	56.0	56.0	0.3374	0.2140	0.0029	0.0051	0.1635	0.0000	0.1635	0.1139	0.0458
N_2O emissions associated with Biomass Burning (CO_2-e)	N_2O	22.79	43.66	30.0	41.7	51.4	0.0262	0.0379	0.0003	0.0010	0.0126	0.0415	0.0434	0.0007	0.0014
Waste – Wastewater Treatment and Discharge	N_2O	72.89	107.62	10.0	90.0	90.6	0.1479	0.1647	0.0002	0.0024	0.0222	0.0341	0.0407	0.0219	0.0271
Waste – Biological Treatment of Solid Waste	N_2O	1.74	27.72	100.0	150.0	180.3	0.0070	0.0845	0.0006	0.0006	0.0854	0.0878	0.1225	0.0000	0.0071
Waste – Incineration and Open Burning of Waste	N_2O	25.76	15.34	50.0	100.0	111.8	0.0645	0.0290	0.0004	0.0003	0.0421	0.0243	0.0486	0.0042	0.0008
Tokelau Energy Industries – Sectoral Approach – Liquid	N_2O	0.00	0.00	10.0	50.0	51.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tokelau Gas Diesel Oil – Sectoral Approach – Liquid	N_2O	0.01	0.01	50.0	50.0	70.7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tokelau Other/ Residential – Sectoral Approach – Liquid	N_2O	0.00	0.00	20.0	50.0	53.9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tokelau IPPU – Other Product Manufacture and Use	N_2O	0.04	0.02	15.0	0.0	15.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tokelau Waste – Wastewater Treatment and Discharge	N_2O	0.02	0.00	10.0	90.0	90.6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tokelau Waste – Incineration and Open Burning of Waste	N_2O	0.01	0.01	50.0	100.0	111.8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO_2-e)	2022 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 2022 (%)	Type A sensitivity (%)	Type B sensitivity (%)	Uncertainty in the trend in national total introduced by emission or removal factor uncertainty (%)	Uncertainty in the 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 2022
2.F.1 Refrigeration and Air Conditioning	HFCs	0.00	1,422.69	24.0	0.0	24.0	0.0000	0.5772	0.0319	0.0319	0.0000	1.0819	1.0819	0.0000	0.3331
2.F.2 Foam Blowing Agents	HFCs	0.00	5.55	12.0	50.0	51.4	0.0000	0.0048	0.0001	0.0001	0.0062	0.0021	0.0066	0.0000	0.0000
2.F.3 Fire Protection	HFCs	0.00	2.24	30.0	30.0	42.4	0.0000	0.0016	0.0001	0.0001	0.0015	0.0021	0.0026	0.0000	0.0000
2.F.4 Aerosols	HFCs	0.00	67.79	25.0	10.0	26.9	0.0000	0.0309	0.0015	0.0015	0.0152	0.0537	0.0558	0.0000	0.0010
Tokelau IPPU – Product Uses as Substitutes for ODS	HFCs	0.00	0.21	24.0	0.0	24.0	0.0000	0.0001	0.0000	0.0000	0.0000	0.0002	0.0002	0.0000	0.0000
2.C.3.a Aluminium	PFCs	818.01	50.93	5.0	30.0	30.4	0.5574	0.0262	0.0231	0.0011	0.6944	0.0081	0.6944	0.3107	0.0007
2.F.1 Refrigeration and Air Conditioning	PFCs	0.00	0.00	25.0	0.0	25.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.2 Other Product Use	PFCs	0.00	0.00	80.0	0.0	80.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.C.4 Magnesium Production	SF_6	2.82	0.00	100.0	30.0	104.4	0.0066	0.0000	0.0001	0.0000	0.0025	0.0000	0.0025	0.0000	0.0000
2.G.1 Electrical Equipment	SF_6	14.95	16.60	20.0	30.0	36.1	0.0121	0.0101	0.0001	0.0004	0.0022	0.0105	0.0107	0.0001	0.0001
2.G.2 Other product Use	SF_6	2.82	2.82	80.0	0.0	80.0	0.0051	0.0038	0.0000	0.0001	0.0000	0.0071	0.0071	0.0000	0.0000
		Total emissions/ removals in 1990	**Total emissions/ removals in 2022**										**Uncertainty in the trend**	**Uncertainty in the base year**	**Uncertainty in the final year**
		44,633.6	**59,156.6**										**23.6%**	**38.5%**	**24.3%**

Table A2.1.2 Uncertainty calculation of the gross emissions and removals for New Zealand in 2022

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO_2-e)	2022 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 2022 (%)	Type A sensitivity (%)	Type B sensitivity (%)	Uncertainty in the trend in national total introduced by emission or removal factor uncertainty (%)	Uncertainty in the 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 2022
Energy – Gaseous Fuels	CO_2	7,026.45	5,710.19	3.5	2.4	4.2	0.4328	0.3094	0.0330	0.0828	0.0795	0.4096	0.4173	0.1873	0.0957
Energy – Liquid Fuels	CO_2	11,789.48	18,676.48	0.7	0.5	0.9	0.1492	0.2079	0.0763	0.2708	0.0382	0.2740	0.2766	0.0223	0.0432
Energy – Other Fossil Fuels	CO_2	0.02	64.96	5.0	5.0	7.1	0.0000	0.0059	0.0009	0.0009	0.0047	0.0067	0.0082	0.0000	0.0000
Energy – Solid Fuels	CO_2	3,211.03	2,632.49	15.2	2.2	15.4	0.7161	0.5164	0.0148	0.0382	0.0321	0.8219	0.8225	0.5127	0.2666
Energy – Fugitive – Oil Exploration	CO_2	0.00	0.00	0.7	100.0	100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Energy – Fugitive – Oil Production	CO_2	0.00	0.00	0.7	100.0	100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Energy – Fugitive – Oil Transport	CO_2	0.01	0.00	0.7	100.0	100.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Energy – Fugitive – Gas Production	CO_2	0.21	0.18	3.5	100.0	100.1	0.0003	0.0002	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000
Energy – Fugitive – Gas Transmission and Storage	CO_2	0.01	0.27	3.5	100.0	100.1	0.0000	0.0003	0.0000	0.0000	0.0004	0.0000	0.0004	0.0000	0.0000
Energy – Fugitive – Gas Distribution	CO_2	1.45	0.30	3.5	100.0	100.1	0.0021	0.0004	0.0000	0.0000	0.0020	0.0000	0.0020	0.0000	0.0000
Energy – Fugitive – Venting and Flaring	CO_2	229.48	441.43	3.5	2.4	4.2	0.0141	0.0239	0.0026	0.0064	0.0063	0.0317	0.0323	0.0002	0.0006
Energy – Fugitive – Other Forms of Energy Production	CO_2	228.58	419.45	5.0	5.0	7.1	0.0234	0.0378	0.0023	0.0061	0.0116	0.0430	0.0445	0.0005	0.0014
2.A.1 Cement Production	CO_2	448.75	408.36	1.0	1.0	1.4	0.0092	0.0074	0.0015	0.0059	0.0015	0.0084	0.0085	0.0001	0.0001
2.A.2 Lime Production	CO_2	82.60	101.48	2.0	2.0	2.8	0.0034	0.0037	0.0001	0.0015	0.0002	0.0042	0.0042	0.0000	0.0000
2.A.4.a Ceramics	CO_2	0.01	0.01	50.0	20.0	53.9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.A.4.b Other Uses of Soda Ash	CO_2	5.87	7.08	3.0	2.0	3.6	0.0003	0.0003	0.0000	0.0001	0.0000	0.0004	0.0004	0.0000	0.0000
2.A.4.d Other – Other Uses of Limestone	CO_2	24.63	48.68	3.0	2.0	3.6	0.0013	0.0022	0.0003	0.0007	0.0006	0.0030	0.0031	0.0000	0.0000
2.B.1 Ammonia Production	CO_2	21.68	19.54	2.0	6.0	6.3	0.0020	0.0016	0.0001	0.0003	0.0004	0.0008	0.0009	0.0000	0.0000
2.B.5.b Calcium Carbide	CO_2	1.43	1.43	50.0	50.0	70.7	0.0015	0.0013	0.0000	0.0000	0.0001	0.0015	0.0015	0.0000	0.0000
2.B.10 Hydrogen Production	CO_2	152.29	14.38	2.0	6.0	6.3	0.0140	0.0012	0.0023	0.0002	0.0138	0.0006	0.0138	0.0002	0.0000
2.C.1 Iron and Steel	CO_2	1,306.73	1,541.56	5.0	7.0	8.6	0.1630	0.1692	0.0008	0.0224	0.0057	0.1581	0.1582	0.0266	0.0286

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO_2-e)	2022 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 2022 (%)	Type A sensitivity (%)	Type B sensitivity (%)	Uncertainty in the trend in national total introduced by emission or removal factor uncertainty (%)	Uncertainty in the 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 2022
2.C.3.a Aluminium	CO_2	448.98	543.93	5.0	2.0	5.4	0.0351	0.0374	0.0005	0.0079	0.0010	0.0558	0.0558	0.0012	0.0014
2.C.5 Secondary Lead Production	CO_2	1.80	0.00	50.0	50.0	70.7	0.0018	0.0000	0.0000	0.0000	0.0015	0.0000	0.0015	0.0000	0.0000
2.D.1 Lubricant Use	CO_2	22.83	34.68	20.0	50.0	53.9	0.0178	0.0238	0.0001	0.0005	0.0063	0.0142	0.0156	0.0003	0.0006
2.D.2 Paraffin Wax	CO_2	2.35	2.35	20.0	100.0	102.0	0.0035	0.0031	0.0000	0.0000	0.0005	0.0010	0.0011	0.0000	0.0000
2.D.3 Other: Urea Catalyst in Road Transport	CO_2	0.00	4.21	50.0	10.0	51.0	0.0000	0.0027	0.0001	0.0001	0.0006	0.0043	0.0044	0.0000	0.0000
Agriculture – Liming	CO_2	296.48	445.62	3.4	50.0	50.1	0.2155	0.2849	0.0016	0.0065	0.0787	0.0311	0.0846	0.0464	0.0812
Agriculture – Urea Application	CO_2	39.19	404.93	10.0	50.0	51.0	0.0290	0.2634	0.0052	0.0059	0.2613	0.0830	0.2742	0.0008	0.0694
Waste – Incineration and Open Burning of Waste	CO_2	153.59	83.33	50.0	40.0	64.0	0.1426	0.0681	0.0013	0.0012	0.0529	0.0855	0.1005	0.0203	0.0046
Tokelau Energy Industries – Sectoral Approach – Liquid	CO_2	0.23	1.33	10.0	7.0	12.2	0.0000	0.0002	0.0000	0.0000	0.0001	0.0003	0.0003	0.0000	0.0000
Tokelau Gas Diesel Oil – Sectoral Approach – Liquid	CO_2	0.90	1.31	50.0	1.5	50.0	0.0007	0.0008	0.0000	0.0000	0.0000	0.0013	0.0013	0.0000	0.0000
Tokelau Other/ Residential – Sectoral Approach – Liquid	CO_2	0.12	0.10	20.0	7.0	21.2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tokelau Waste – Incineration and Open Burning of Waste	CO_2	0.05	0.04	50.0	40.0	64.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Energy – Gaseous Fuels	CH_4	10.14	4.19	3.5	50.0	50.1	0.0074	0.0027	0.0001	0.0001	0.0053	0.0003	0.0053	0.0001	0.0000
Energy – Liquid Fuels	CH_4	98.02	38.81	0.7	50.0	50.0	0.0711	0.0248	0.0011	0.0006	0.0527	0.0006	0.0527	0.0051	0.0006
Energy – Other Fossil Fuels	CH_4	0.01	0.07	5.0	50.0	50.2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Energy – Solid Fuels	CH_4	40.71	18.38	15.2	50.0	52.3	0.0309	0.0123	0.0004	0.0003	0.0202	0.0057	0.0210	0.0010	0.0002
Energy – Biomass	CH_4	77.76	70.68	50.0	50.0	70.7	0.0797	0.0638	0.0003	0.0010	0.0128	0.0725	0.0736	0.0064	0.0041
Energy – Fugitive – Coal Handling	CH_4	367.40	64.32	15.2	50.0	52.3	0.2785	0.0429	0.0051	0.0009	0.2562	0.0201	0.2570	0.0775	0.0018
Energy – Fugitive – Oil Exploration	CH_4	0.00	0.00	0.7	50.0	50.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Energy – Fugitive – Oil production	CH_4	0.07	0.02	0.7	50.0	50.0	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO_2-e)	2022 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 2022 (%)	Type A sensitivity (%)	Type B sensitivity (%)	Uncertainty in the trend in national total introduced by emission or removal factor uncertainty (%)	Uncertainty in the 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 2022
Energy – Fugitive – Oil Transport	CH_4	1.88	0.80	0.7	50.0	50.0	0.0014	0.0005	0.0000	0.0000	0.0010	0.0000	0.0010	0.0000	0.0000
Energy – Fugitive – Oil Refining	CH_4	3.06	0.69	0.7	50.0	50.0	0.0022	0.0004	0.0000	0.0000	0.0020	0.0000	0.0020	0.0000	0.0000
Energy – Fugitive – Gas Production	CH_4	160.67	140.24	3.5	50.0	50.1	0.1168	0.0897	0.0006	0.0020	0.0307	0.0101	0.0324	0.0136	0.0080
Energy – Fugitive – Gas Transmission and Storage	CH_4	2.77	30.90	3.5	100.0	100.1	0.0040	0.0394	0.0004	0.0004	0.0402	0.0022	0.0403	0.0000	0.0016
Energy – Fugitive – Gas Distribution	CH_4	310.78	34.47	3.5	100.0	100.1	0.4510	0.0440	0.0046	0.0005	0.4624	0.0025	0.4624	0.2034	0.0019
Energy – Fugitive – Venting and Flaring	CH_4	181.62	45.27	3.5	50.0	50.1	0.1320	0.0289	0.0023	0.0007	0.1169	0.0032	0.1169	0.0174	0.0008
Energy – Fugitive – Other Forms of Energy Production	CH_4	61.37	113.13	5.0	50.0	50.2	0.0447	0.0725	0.0006	0.0016	0.0314	0.0116	0.0335	0.0020	0.0053
2.B.8 Methanol	CH_4	30.91	78.12	2.0	80.0	80.0	0.0359	0.0797	0.0006	0.0011	0.0499	0.0032	0.0500	0.0013	0.0064
Agriculture – Enteric Fermentation	CH_4	31,212.52	32,617.20	3.9	15.5	16.0	7.2421	6.6570	0.0414	0.4730	0.6422	2.6088	2.6867	52.4477	44.3152
Agriculture – Manure Management	CH_4	829.90	1,803.70	5.0	20.0	20.6	0.2481	0.4743	0.0125	0.0262	0.2495	0.1850	0.3105	0.0616	0.2250
Agriculture – Burning of Residues	CH_4	25.34	17.94	6.0	20.0	20.9	0.0077	0.0048	0.0002	0.0003	0.0032	0.0022	0.0038	0.0001	0.0000
Waste – Solid Waste Disposal	CH_4	3,708.78	2,840.62	86.3	40.0	95.1	5.1164	3.4470	0.0199	0.0412	0.7976	5.0282	5.0910	26.1772	11.8817
Waste – Wastewater Treatment and Discharge	CH_4	250.92	287.40	10.0	40.0	41.2	0.1500	0.1512	0.0000	0.0042	0.0012	0.0589	0.0590	0.0225	0.0228
Waste – Biological Treatment of Solid Waste	CH_4	3.07	48.81	100.0	100.0	141.4	0.0063	0.0880	0.0007	0.0007	0.0657	0.1001	0.1197	0.0000	0.0078
Waste – Incineration and Open Burning of Waste	CH_4	139.99	81.88	50.0	100.0	111.8	0.2270	0.1168	0.0011	0.0012	0.1121	0.0840	0.1400	0.0515	0.0136
Tokelau Energy Industries – Sectoral Approach – Liquid	CH_4	0.00	0.00	10.0	50.0	51.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tokelau Gas Diesel Oil – Sectoral Approach – Liquid	CH_4	0.00	0.00	50.0	50.0	70.7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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Tokelau Other/ Residential – Sectoral Approach – Liquid	CH_4	0.00	0.00	20.0	50.0	53.9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tokelau Agriculture – Enteric Fermentation	CH_4	0.10	0.07	20.0	50.0	53.9	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tokelau Agriculture – Manure Management	CH_4	1.19	0.85	20.0	30.0	36.1	0.0006	0.0004	0.0000	0.0000	0.0002	0.0004	0.0004	0.0000	0.0000
Tokelau Waste – Solid Waste Disposal	CH_4	0.44	0.35	140.0	40.0	145.6	0.0009	0.0006	0.0000	0.0000	0.0001	0.0010	0.0010	0.0000	0.0000
Tokelau Waste – Wastewater Treatment and Discharge	CH_4	0.17	0.30	10.0	40.0	41.2	0.0001	0.0002	0.0000	0.0000	0.0001	0.0001	0.0001	0.0000	0.0000
Tokelau Waste – Incineration and Open Burning of Waste	CH_4	0.10	0.08	50.0	100.0	111.8	0.0002	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000
Energy – Gaseous Fuels	N_2O	4.92	2.61	3.5	50.0	50.1	0.0036	0.0017	0.0000	0.0000	0.0022	0.0002	0.0022	0.0000	0.0000
Energy – Liquid Fuels	N_2O	140.43	158.91	0.7	50.0	50.0	0.1018	0.1014	0.0000	0.0023	0.0005	0.0023	0.0024	0.0104	0.0103
Energy – Other Fossil Fuels	N_2O	0.18	0.13	5.0	50.0	50.2	0.0001	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000
Energy – Solid Fuels	N_2O	13.25	10.49	15.2	50.0	52.3	0.0100	0.0070	0.0001	0.0002	0.0033	0.0033	0.0047	0.0001	0.0000
Energy – Biomass	N_2O	36.54	36.21	50.0	50.0	70.7	0.0375	0.0327	0.0001	0.0005	0.0039	0.0371	0.0373	0.0014	0.0011
Energy – Fugitive – Venting and Flaring	N_2O	0.05	0.02	3.5	100.0	100.1	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000
2.G.3 N_2O from Product Uses	N_2O	88.76	94.74	15.0	0.0	15.0	0.0193	0.0181	0.0001	0.0014	0.0000	0.0291	0.0291	0.0004	0.0003
Agriculture – Agricultural Soils	N_2O	4,668.99	6,322.49	14.3	54.2	56.1	3.7953	4.5207	0.0147	0.0917	0.7969	1.8542	2.0182	14.4045	20.4371
Agriculture – Manure Management	N_2O	44.86	97.86	5.0	100.0	100.1	0.0651	0.1250	0.0007	0.0014	0.0680	0.0100	0.0687	0.0042	0.0156
Agriculture – Burning of Residues	N_2O	4.24	2.95	6.0	20.0	20.9	0.0013	0.0008	0.0000	0.0000	0.0005	0.0004	0.0007	0.0000	0.0000
Waste – Wastewater Treatment and Discharge	N_2O	72.89	107.62	10.0	90.0	90.6	0.0957	0.1243	0.0004	0.0016	0.0323	0.0221	0.0391	0.0092	0.0155

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Waste – Biological Treatment of Solid Waste	N_2O	1.74	27.72	100.0	150.0	180.3	0.0046	0.0637	0.0004	0.0004	0.0560	0.0568	0.0798	0.0000	0.0041
Waste – Incineration and Open Burning of Waste	N_2O	25.76	15.34	50.0	100.0	111.8	0.0418	0.0219	0.0002	0.0002	0.0202	0.0157	0.0256	0.0017	0.0005
Tokelau Energy Industries – Sectoral Approach – Liquid	N_2O	0.00	0.00	10.0	50.0	51.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tokelau Gas Diesel Oil – Sectoral Approach – Liquid	N_2O	0.01	0.01	50.0	50.0	70.7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tokelau Other/ Residential – Sectoral Approach – Liquid	N_2O	0.00	0.00	20.0	50.0	53.9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tokelau IPPU – Other product manufacture and use	N_2O	0.04	0.02	15.0	0.0	15.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tokelau Waste – Wastewater Treatment and Discharge	N_2O	0.02	0.00	10.0	90.0	90.6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tokelau Waste – Incineration and Open Burning of Waste	N_2O	0.01	0.01	50.0	100.0	111.8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.F.1 Refrigeration and Air Conditioning	HFCs	0.00	1,422.69	24.0	0.0	24.0	0.0000	0.4355	0.0206	0.0206	0.0000	0.7002	0.7002	0.0000	0.1897
2.F.2 Foam Blowing Agents	HFCs	0.00	5.55	12.0	50.0	51.4	0.0000	0.0036	0.0001	0.0001	0.0040	0.0014	0.0042	0.0000	0.0000
2.F.3 Fire Protection	HFCs	0.00	2.24	30.0	30.0	42.4	0.0000	0.0012	0.0000	0.0000	0.0010	0.0014	0.0017	0.0000	0.0000
2.F.4 Aerosols	HFCs	0.00	67.79	25.0	10.0	26.9	0.0000	0.0233	0.0010	0.0010	0.0098	0.0348	0.0361	0.0000	0.0005
Tokelau IPPU – Product Uses as Substitutes for ODS	HFCs	0.00	0.21	24.0	0.0	24.0	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000
2.C.3.a Aluminium	PFCs	818.01	50.93	5.0	30.0	30.4	0.3608	0.0198	0.0127	0.0007	0.3824	0.0052	0.3824	0.1302	0.0004
2.F.1 Refrigeration and Air Conditioning	PFCs	0.00	0.00	25.0	0.0	25.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.G.2 Other Product Use	PFCs	0.00	0.00	80.0	0.0	80.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO_2-e)	2022 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 2022 (%)	Type A sensitivity (%)	Type B sensitivity (%)	Uncertainty in the trend in national total introduced by emission or removal factor uncertainty (%)	Uncertainty in the 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 2022
2.C.4 Magnesium Production	SF_6	2.82	0.00	100.0	30.0	104.4	0.0043	0.0000	0.0000	0.0000	0.0014	0.0000	0.0014	0.0000	0.0000
2.G.1 Electrical Equipment	SF_6	14.95	16.60	20.0	30.0	36.1	0.0078	0.0076	0.0000	0.0002	0.0002	0.0068	0.0068	0.0001	0.0001
2.G.2 Other Product Use	SF_6	2.82	2.82	80.0	0.0	80.0	0.0033	0.0029	0.0000	0.0000	0.0000	0.0046	0.0046	0.0000	0.0000
		Total emissions/ removals in 1990	**Total emissions/ removals in 2022**										**Uncertainty in the trend**	**Uncertainty in the base year**	**Uncertainty in the final year**
		68,958.2	**78,395.4**										**6.3%**	**9.7%**	**8.8%**

Annex 2: Reference

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 3: Carbon dioxide reference approach for the Energy sector

A3.1 Estimation of carbon dioxide using the IPCC reference approach

The reference approach uses a country's energy supply data to calculate the carbon dioxide (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 5, section A5.3.4). 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 Intergovernmental Panel on Climate Change (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 carbon content and gross calorific value data provided by New Zealand's only oil refinery (up until 2021) or provided by fuel importers (starting in 2022). Where these data are not available, an IPCC default value 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 reported as production activity data in the reference approach is used in steel production. The Industrial Processes and Product Use sector reports the CO_2 emissions from the coal used for steel production as recommended by the IPCC Guidelines (IPCC, 2006); therefore these emissions are not included in the common reporting table 1.AA *Fuel combustion*.

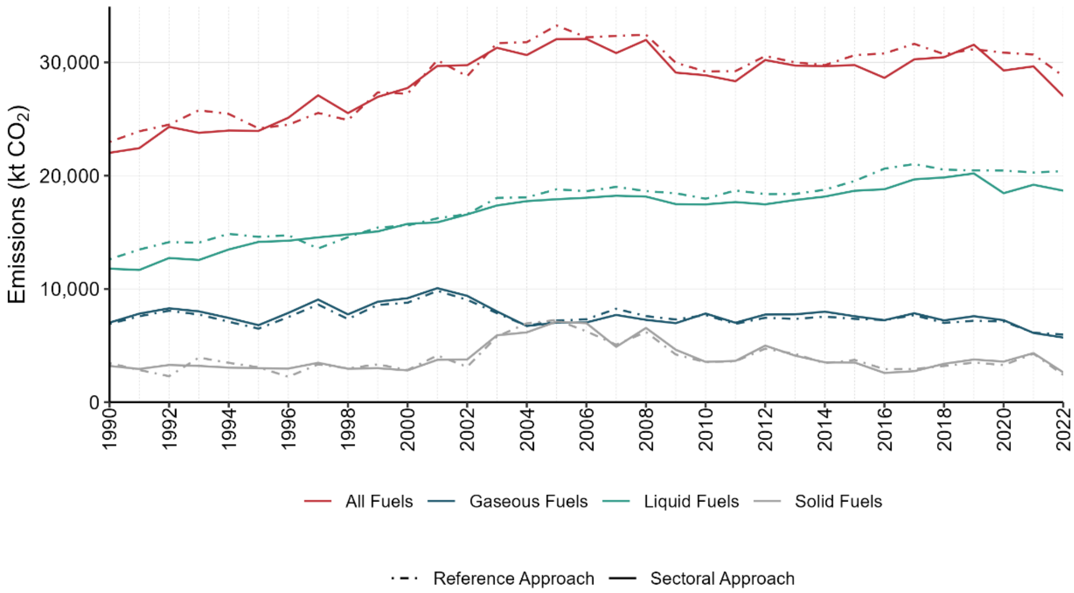
For simplicity, all feedstock carbon is excluded from the reference approach according to the IPCC Guidelines (IPCC, 2006). Without taking into account the use of by-product gases, this can create some discrepancies between the reference and sectoral approaches.

A3.2 Comparison of the IPCC reference approach with the New Zealand sectoral methodology

For 2022, CO_2 emissions estimated with the sectoral approach were 6.2 per cent lower than those estimated with the reference approach. Figure A3.2.1 shows the results for the two approaches for the period 1990 to 2022.

In some years, differences exist between the reference and sectoral approaches. In large part, these differences are due to the statistical differences found in the energy balance tables (Ministry of Business, Innovation and Employment, 2023) 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. Before 2008, various energy statistics were collected by Stats NZ or the Ministry of Business, Innovation and Employment. In 2008, Stats NZ delegated responsibility for the collection and analysis of national energy data to Ministry of Business, Innovation and Employment. The change resulted in a more consistent and transparent approach to energy data collection because one agency collected data across the supply chain.

Figure A3.2.1 Reference and sectoral approaches to carbon dioxide by fuel type (kilotonnes carbon dioxide)



Sources of differences

- A statistical difference in the national energy balance will translate to a difference between the reference and sectoral approaches.
- 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 3: References

IPCC. 2006. Eggleston HS, Buendia L, Miwa K, Ngara T, Tanabe K (eds). *2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2. Energy*. IPCC National Greenhouse Gas Inventories Programme. Japan: Institute for Global Environmental Strategies for IPCC.

Ministry of Business, Innovation and Employment. 2023. *Energy in New Zealand 2023*. Wellington: Ministry of Business, Innovation and Employment.

Annex 4: Quality-assurance and quality-control plan

A4.1 Quality-assurance and quality-control processes applied to all sectors

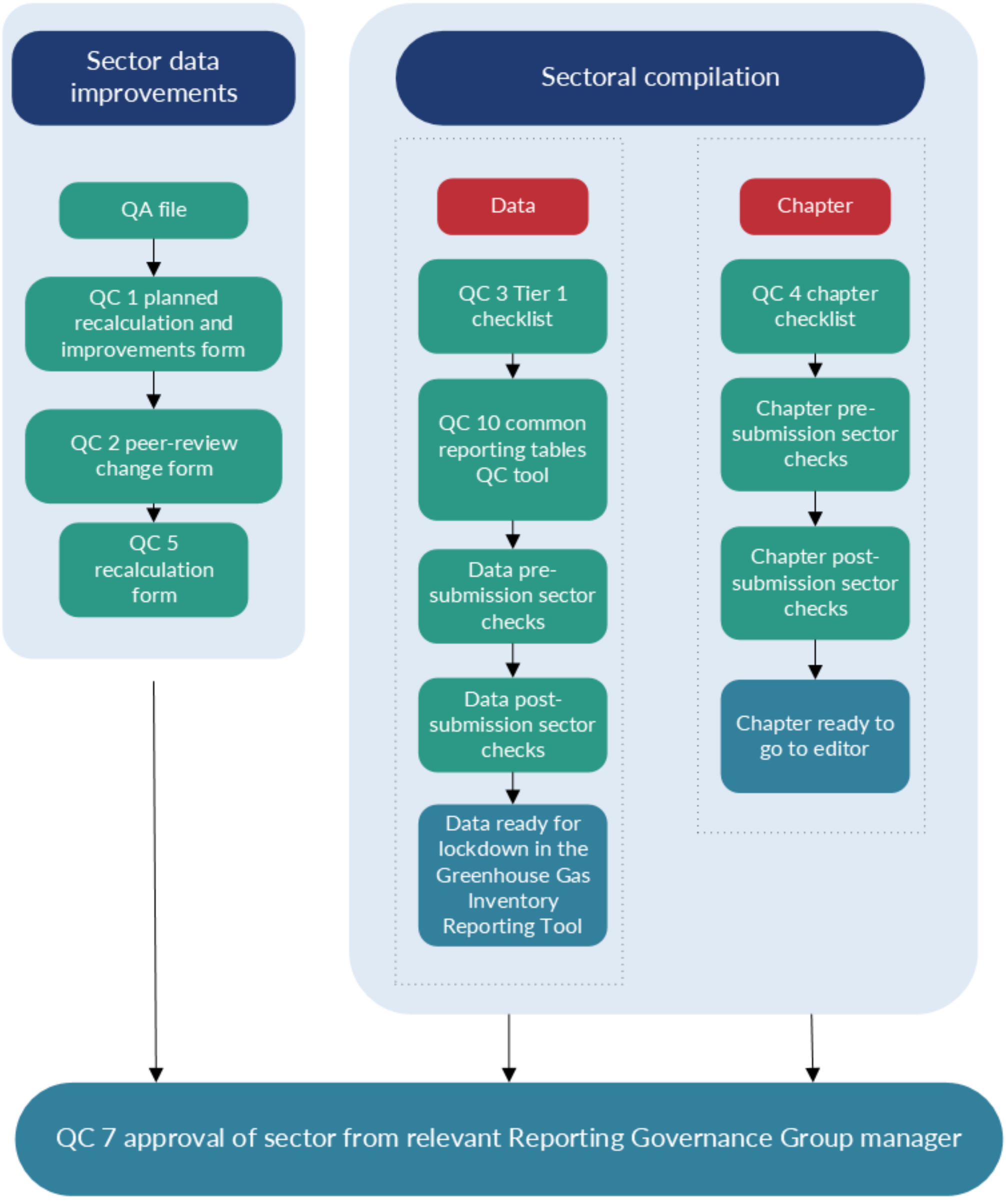
Quality-assurance and quality-control (QA/QC) processes have a significant role in the preparation of the inventory, to ensure the core principles of transparency, accuracy, completeness, comparability and consistency are achieved. Table A4.1.1 describes the main QA/QC processes used in the preparation of the inventory sectors. These processes are under continual review and improvement, to ensure they are fit for purpose.

Table A4.1.1 Quality-assurance and quality-control (QA/QC) processes used in preparation of the inventory sectors

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 international climate change reporting by the New Zealand Government. The role of this group is further described in chapter 1.
QC 2	If planned improvements affect emission factors, parameters, methodologies or activity data sources, they are peer reviewed before being implemented. 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 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 table QC tools identify any potential issues with the data and are used to ensure data integrity standards are met.
Sector pre-submission and post-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.

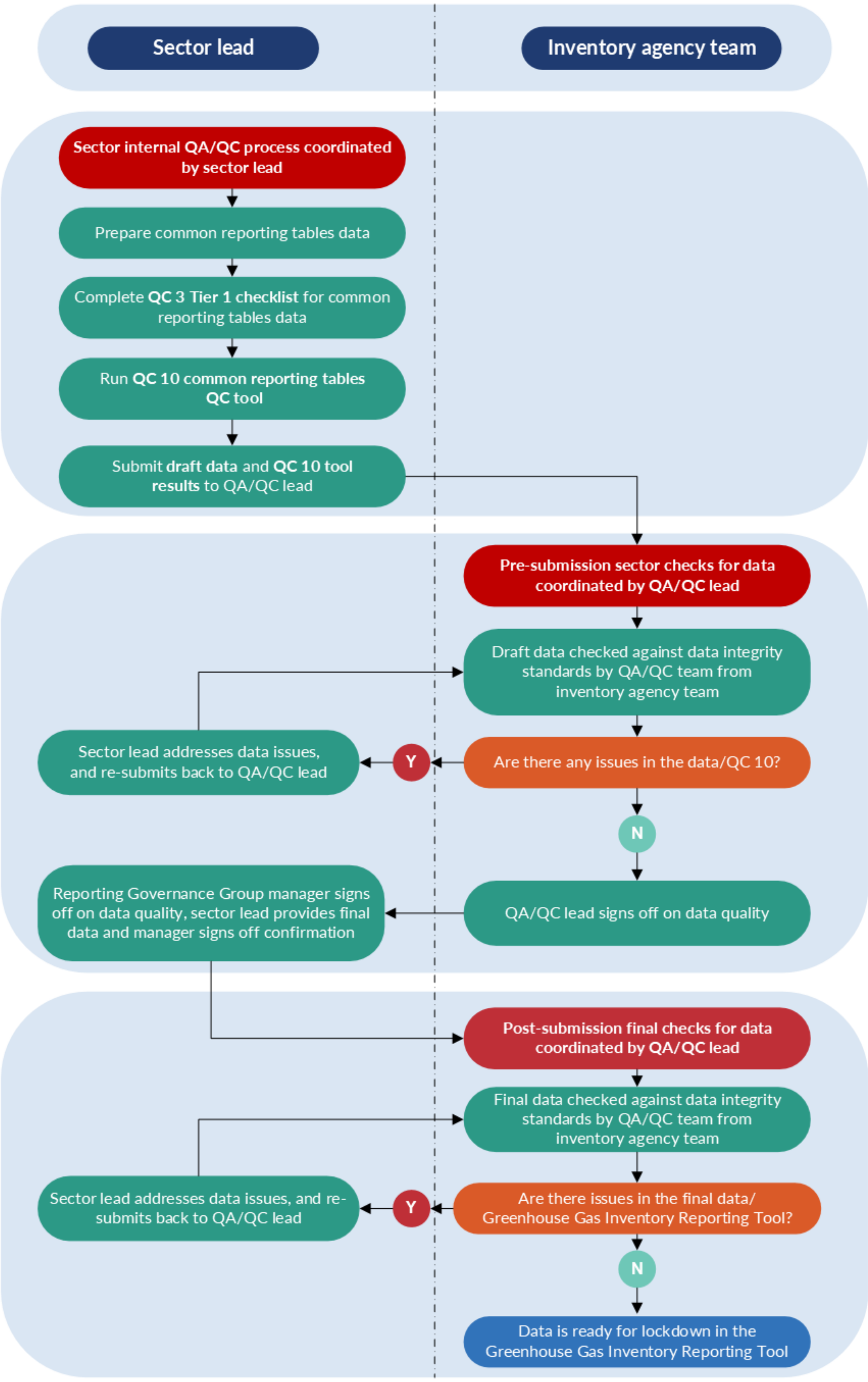
Figure A4.1.1 presents an overview of QA/QC processes and how they align with the sector data improvements and sectoral compilation of data and chapters. Figures A4.1.2 and A4.1.3 show process diagrams for pre-submission and post-submission sector checks for data and chapters, while figure A4.1.4 lists all those checks.

Figure A4.1.1 Overview of quality-assurance and quality-control (QA/QC) processes and how they align with the sector data improvements and sectoral compilation of data and chapters



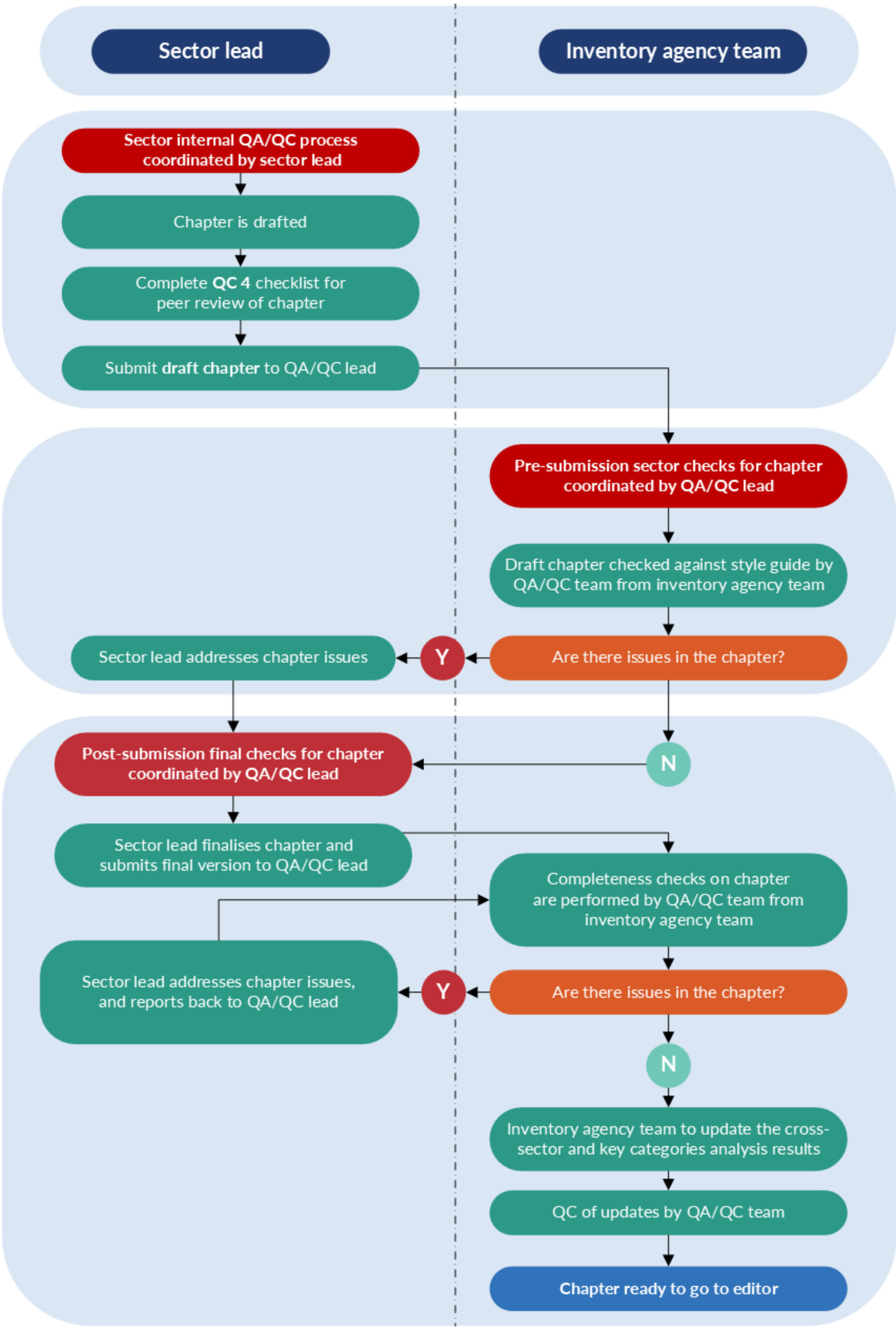
Note: See table A4.1.1: Quality-assurance and quality-control (QA/QC) processes used in preparation of the inventory sectors.

Figure A4.1.2 Diagram of quality-assurance and quality-control (QA/QC) processes for sectoral compilation of data



Note: See table A4.1.1: Quality-assurance and quality-control (QA/QC) processes used in preparation of the inventory sectors.

Figure A4.1.3 Diagram of quality-assurance and quality-control (QA/QC) processes for sectoral compilation of chapter



Note: See table A4.1.1: Quality-assurance and quality-control (QA/QC) processes used in preparation of the inventory sectors.

Figure A4.1.4 Pre-submission and post-submission sector checks process for data and chapters

Pre-submission checks

Data

Detailed review of data quality against standards in QC 10 tool:

- Entry of all required data in the common reporting table
- Time series consistency for implied emission factor
- Changes in entered data type are adequately explained
- Included elsewhere and not-estimated notation keys are adequately explained
- Methodological tiers and emission factors are compliant with the 2006 IPCC Guidelines (IPCC, 2006)
- Unique data in the final data year to avoid duplicates

Chapters

Detailed review of National Inventory Report content against chapter standards:

- Text formatting
- Heading and content match National Inventory Report
- Subcategory and per cent check
- Category names are italicised
- Decimal place rules applied
- Graph rules applied

Post-submission checks

Data

Review of data quality in Greenhouse Gas Inventory Reporting Tool:

QC checks:

- Completeness checks
- Consistency checks

QA checks:

- Not occurring activity data
- Confidential aggregation
- Time series consistency
- Sum of the specified categories from energy and agriculture add up to 100 per cent

Final review of data quality against standards in QC 10 tool versus the Greenhouse Gas Inventory Reporting Tool

Chapters

Review of National Inventory Report content:

- Chapters overview check
- Uncertainties in sector chapters check

QA – quality assurance QC – quality control
IPCC – Intergovernmental Panel on Climate Change

Note: See table A4.1.1: Quality-assurance and quality-control (QA/QC) processes used in preparation of the inventory sectors.

Annex 4: Reference

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 5: Additional information, including detailed methodological descriptions of source or sink categories and the national emission balance

This annex contains supplementary information for the Agriculture sector (A5.1), the Land Use, Land-use Change and Forestry (LULUCF) sector (A5.2) and the Energy sector (A5.3).

A5.1 Supplementary information for the Agriculture sector

A5.1.1 Livestock population data

Agricultural Production Survey 2021 and Agricultural Production Census 2022

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-year-to-june-2022-final).

Stats NZ conducts the APC every five years, most recently in 2022. The final results from the 2022 APC were released in mid-2023. 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 2021 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 2021). The response rate, or the estimated proportion of eligible businesses that responded to the 2022 APC, was 73 per cent.

The imputation levels of the 2021 APS and 2022 APC are provided in table A5.1.1. 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 A5.1.1 Imputation levels and sampling errors for the Agricultural Production Survey in 2021 and Agricultural Production Census in 2022

	Proportion of total estimate imputed (%)		Relative sampling errors at 95% confidence interval (%)	
Survey year	**2021**	**2022**	**2021**	**2022**
Ewe hoggets put to ram	19	28	6	NA
Breeding ewes, two tooth and over	22	30	3	NA
Total number of sheep	**21**	**30**	**3**	**NA**
Lambs born to ewe hoggets	19	29	6	NA
Lambs born to ewes	22	30	3	NA
Total number of lambs	**21**	**30**	**3**	**NA**
Calves born alive to dairy heifers and/or cows	30	29	4	NA
Dairy cows and heifers, in milk or calf	29	34	4	NA
Total number of dairy cattle	**28**	**33**	**4**	**NA**
Calves born alive to beef heifers and/or cows	23	29	3	NA
Beef cows and heifers (in calf) one to two years	22	27	9	NA
Beef cows and heifers (in calf) two years and over	23	27	3	NA
Total number of beef cattle	**23**	**28**	**3**	**NA**
Female deer mated	15	27	6	NA
Total number of deer	**16**	**29**	**6**	**NA**
Fawns born on farm and alive at four months	15	28	5	NA
Total pigs	**1**	**5**	**0**	**NA**
Area of wheat harvested	15	35	5	NA
Area of barley harvested	20	34	8	NA
Area of oat grain harvested	20	38	18	NA
Area of maize grain harvested	19	23	13	NA

Note: NA = not applicable.

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 (table A5.1.2) is taken from population data collected by the APC and APS and Ministry for Primary Industries slaughter statistics.

Table A5.1.2 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
	Northland
	Auckland
	Waikato
	Bay of Plenty
	Gisborne
	Hawke's Bay
	Taranaki
	Manawatu–Whanganui
	Wellington

Livestock category	Subcategory
	Tasman
	Nelson
	Marlborough
	West Coast
	Canterbury
	Otago
	Southland
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 heifers two to three years
	Slaughter steers less than one year
	Slaughter steers one to two years
	Slaughter steers two to three years
	Slaughter bulls less than one year
	Slaughter bulls one to two years
	Slaughter bulls two to three 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

A5.1.2 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 A5.1.3 shows the proportions that are used to calculate milk yield for different months over the course of a year. Table A5.1.4 shows the emission factors used to calculate methane emissions from minor livestock species, while tables A5.1.5 and A5.1.6 show the emission factors used to calculate nitrous oxide emissions from agriculture. Table A5.1.7 shows some of the parameter values used to calculate nitrous oxide emissions.

Table A5.1.3 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
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 et al. (2022)

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

Table A5.1.4 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 (2006b), table 10.10	18.0
EF_{MULES}	Enteric fermentation – mules and asses	IPCC (2006b), table 10.10	10.0
EF_{SWINE}	Enteric fermentation – swine	Hill (2012)	1.06
EF_{ALPACA}	Enteric fermentation – alpaca	IPCC (2006b), table 10.10	8.0
MM_{GOATS}	Manure management – goats	IPCC (2006b), table 10.15	0.20
MM_{HORSES}	Manure management – horses	IPCC (2006b), table 10.15	2.34
MM_{MULES}	Manure management – mules and asses	IPCC (2006b), 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

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.

Table A5.1.5 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 (2006b), 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); de Klein et al. (2003); Muller et al. (1995)	0.01
$EF_{3(PRP\ DUNG)}$ (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 urine are reported in table A5.1.6)	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 (2006b), table 11.3	0.01
EF_5 (kg N_2O-N/kg N leached and runoff)	Indirect emissions from leaching nitrogen	IPCC (2006b), table 11.3	0.0075

Table A5.1.6 Direct nitrous oxide emission factors for urine deposited by cattle, sheep and deer, by livestock type and slope

	Emission factor by topography (kg N_2O–N/kg N excreted)	
	Flat and low sloped land (less than 12-degree gradient)	Medium and steep sloped land (greater than 12-degree gradient)
Livestock type	$EF_{3(PRP\text{-}FLAT)}$	$EF_{3(PRP\text{-}STEEP)}$
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 A5.1.7 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 (2006b) 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 runoff	Welten et al. (2021)	0.10 (Cropland) 0.08 (Grassland) 0.082 (Synthetic N fertiliser)
$Frac_{BURN}$ (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

Parameter (fraction)	Fraction of the parameter	Source	Parameter value
$Frac_{RENEW}$	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 A5.1.8. These values are taken from research conducted by Thomas et al. (2008, 2011).

Table A5.1.8 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.

A5.1.3 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 are described in detail in chapter 5, section 5.5.2. That section explains the research behind the revised emission factors and how they are applied to estimate emissions from cattle, sheep and deer on different hill slopes.

These revised emission factors are disaggregated by slope (as well as by 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 involved in this calculation are described below.

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 are not allocated to different slope types because the Agriculture inventory model 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. (2022).

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 et al. (2022).

Step 3: Allocating urine 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 accounts for the preference of animals to spend more time on flatter slopes. Using this model, the proportion of excreta deposited on low slopes is greater than the proportion on low slope land area.

The equations and variables needed to allocate excreta to different slopes are outlined in table A5.1.9 and figures A5.1.1 and A5.1.2. 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.

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

Table A5.1.9 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 A5.1.1 **Proportion of urine nitrogen (N) applied to low (0- to 12-degree) slopes using a nutrient transfer model (equal proportion line shown in grey for comparison)**

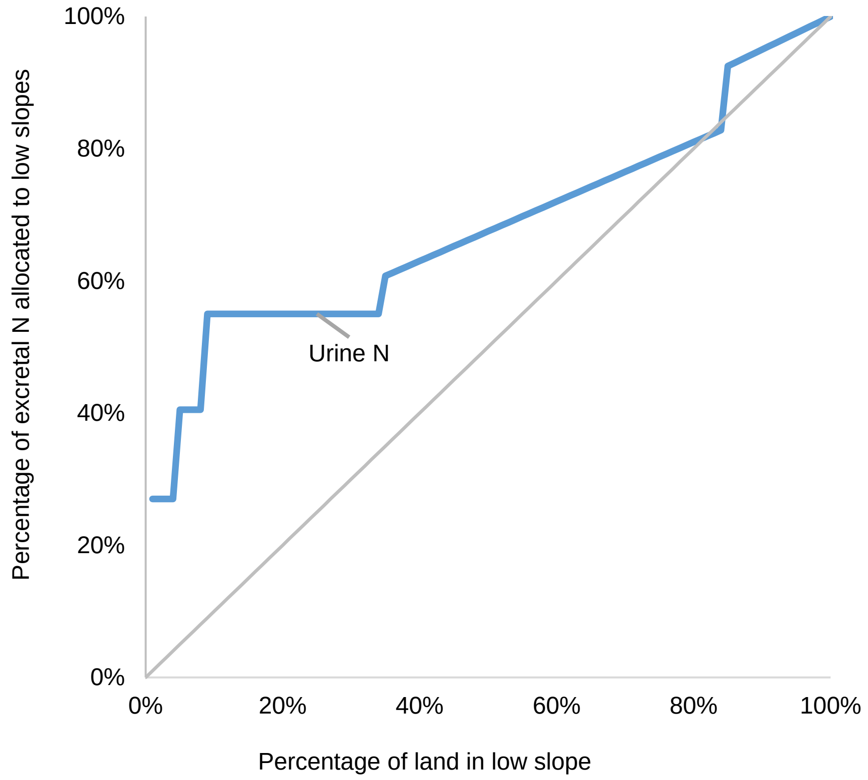
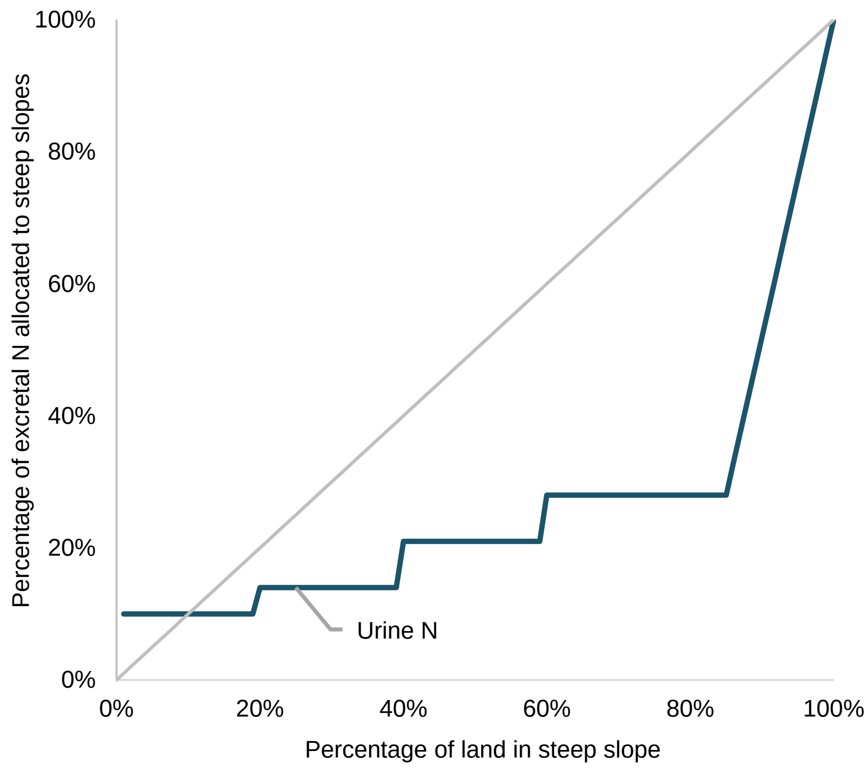


Figure A5.1.2 **Proportion of urine nitrogen (N) applied to steep (more than 24-degree) slopes using a nutrient transfer model (equal proportion line shown in grey for comparison)**



Tables A5.1.10 to A5.1.12 and figure A5.1.3 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 A5.1.11 and A5.1.12).

Table A5.1.10 Share of livestock population, and amount of urine nitrogen (N) deposition in 2022, 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	6.8	19,799,014.0	3.0	7,175,438.7	14.0	2,431,828.3
2. South Island Hill Country	11.7	34,192,598.4	7.6	17,889,996.0	6.3	1,096,997.5
3. North Island Hard Hill Country	17.1	50,027,048.4	14.8	35,011,051.7	9.0	1,561,314.7
4. North Island Hill Country	26.2	76,872,297.1	40.8	96,217,068.9	29.1	5,079,297.0
5. North Island Intensive Finishing	5.6	16,422,622.3	12.2	28,844,321.4	0.4	65,494.5
6. South Island Finishing Breeding	19.2	56,387,068.5	14.4	33,881,585.7	24.9	4,335,796.6
7. South Island Intensive Finishing	10.4	30,441,274.7	2.7	6,350,520.2	11.9	2,070,596.2
8. South Island Mixed Finishing	3.0	8,850,641.8	4.5	10,660,132.2	4.5	783,621.2
Total		**292,992,565.2**		**236,030,114.9**		**17,424,946.1**

Each farm class has a different proportion of land in low, medium and steep slopes, as shown in table A5.1.11. 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 A5.1.11 Proportion of total sheep, beef and deer land on different hill slopes, by Beef + Lamb New Zealand Ltd farm class, for 2021/22

	Land type by slope		
Farm class	Flat/low (0–12° slope) (%)	Rolling/medium (12–24° slope) (%)	Steep (>24° slope) (%)
1. South Island High Country	6.3	26.4	67.3
2. South Island Hill Country	18.3	25.2	56.5
3. North Island Hard Hill Country	8.8	38.4	52.7
4. North Island Hill Country	16.6	53.6	29.8
5. North Island Intensive Finishing	48.8	45.6	5.6
6. South Island Finishing Breeding	34.3	45.3	20.4
7. South Island Intensive Finishing	63.6	36.4	0.0
8. South Island Mixed Finishing	75.6	18.9	5.4
Total sheep, beef and deer land	**21.4**	**38.0**	**40.6**

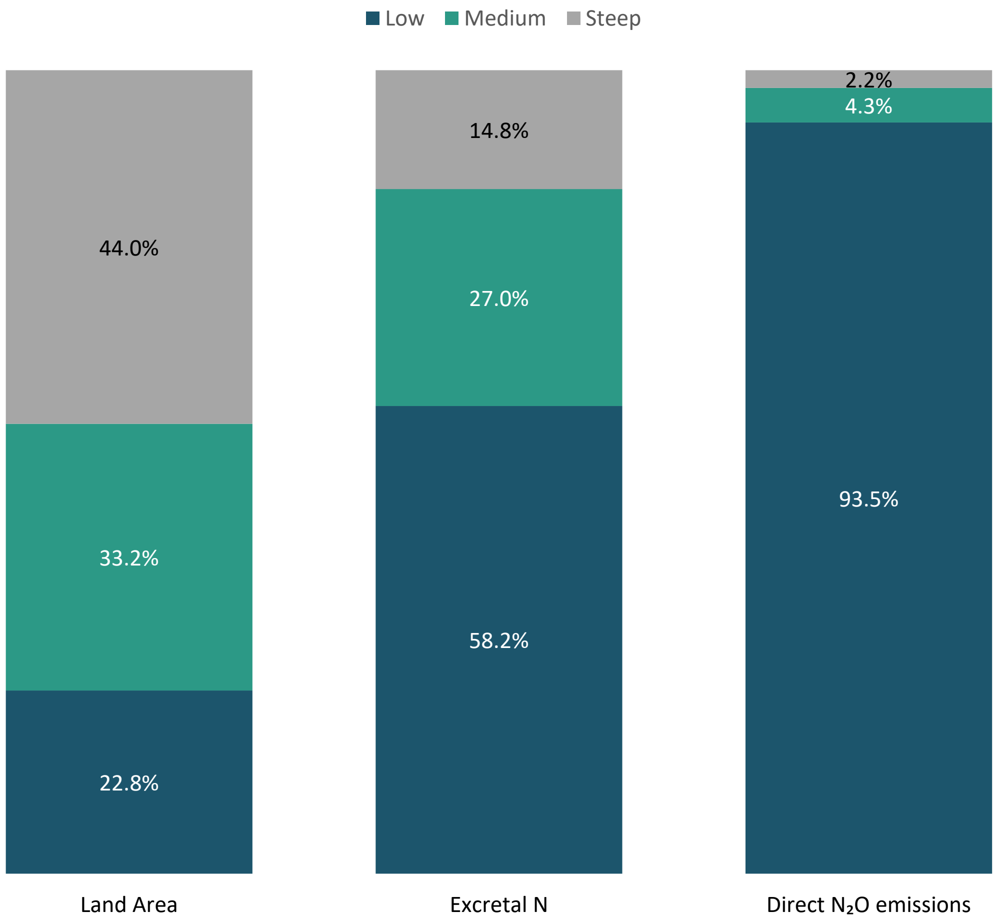
Note: The percentages may not add up to 100 per cent due to rounding.

Table A5.1.12 Proportion of total sheep, beef and deer urine nitrogen deposited on different hill slopes, by Beef + Lamb New Zealand Ltd farm class, for 2022

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	0.67	0.23	0.10
6. South Island Finishing Breeding	0.55	0.31	0.14
7. South Island Intensive Finishing	0.74	0.26	0.00
8. South Island Mixed Finishing	0.79	0.1	0.10
Total sheep urine	**0.55**	**0.30**	**0.15**
Total beef urine	**0.55**	**0.30**	**0.15**
Total deer urine	**0.55**	**0.30**	**0.15**
Total sheep, beef and deer urine	**0.55**	**0.30**	**0.15**

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

Figure A5.1.3 Proportion of land area, urine nitrogen (N) and resultant nitrous oxide (N_2O) emissions by hill slope category for sheep, beef cattle and deer farms in 2022



A5.2 Supplementary information for the LULUCF sector

A5.2.1 Land use mapping methodology

Areas of land use and land-use change between 1990 and 2022 are based on five wall-to-wall land use maps (LUMs) derived from satellite imagery at nominal mapping dates of 31 December 1989, 31 December 2007, 31 December 2012, 31 December 2016 and 31 December 2020. Area information from these maps is interpolated and extrapolated to obtain a complete time series of land-use change occurring between 1990 and 2022.

Satellite image acquisition and pre-processing

Each of the national land use maps is based on a collection of satellite imagery from Landsat, SPOT[2] or Sentinel-2 acquired over the summer periods (October to March) as described in table A5.2.1. Acquisition is limited to the summer months, because a high sun angle is required to reduce topographic shadowing and increase the dynamic range of the signal received from the ground.

Table A5.2.1 Satellite imagery used for land use mapping in 1989, 2007, 2012, 2016 and 2020

Land use map	Satellite imagery	Resolution (metres)	Acquisition period
1989	Landsat 4	30	November 1988 – February 1993
2007	SPOT 5	10	November 2006 – April 2008
2012	SPOT 5	10	October 2011 – March 2013
2016	Sentinel-2	10	October 2016 – March 2017
2020	Sentinel-2	10	October 2020 – March 2021

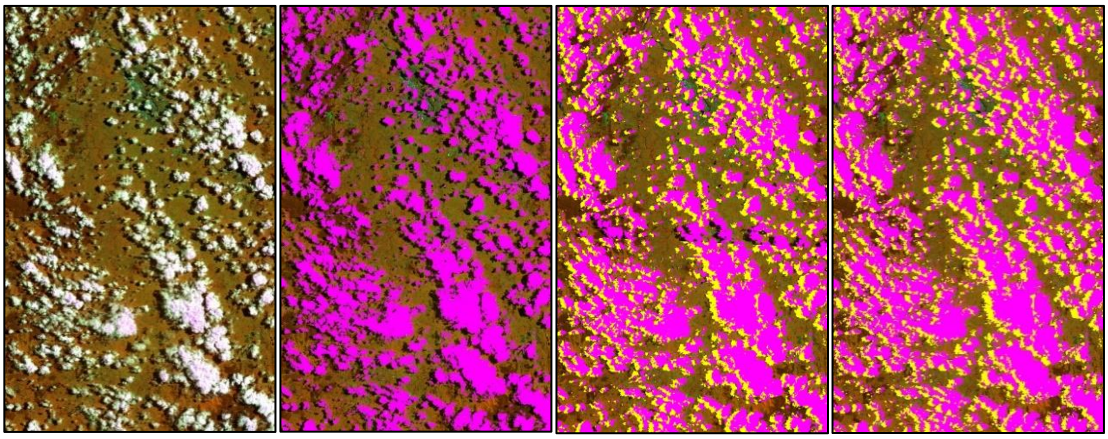
Note: Land use maps are named for the last year of change included in the map so the 2020 LUM has a nominal mapping date of 31 December 2020 and includes land use change occurring up to and in 2020. Satellite mosaics are named with the latest year of imagery included within the mosaic, so the 2021 mosaic is the basis for the 2020 land use map.

All the imagery was orthorectified and then cloud-cleared prior to mosaicking. Accurate identification of cloud and cloud-shadow is a critical step because any undetected cloud could subsequently be labelled as land-use change where there is a high contrast between the cloud and usual land cover. For example, cloud over forest areas could be classed as bare ground and interpreted as a forest clearing event.

To achieve a high level of accuracy in cloud identification, a time-consuming manual process of delineating cloud and cloud-shadow boundaries has historically been used. However, recent advances in automatic mosaicking techniques have made it possible to achieve superior results with a fully automated approach (Shepherd et al., 2020). This technique uses the parallax method (Frantz et al., 2018) to provide a first estimate of cloud and cloud-shadow objects, then refines the result by comparing the Top of Atmosphere (TOA) reflectance of each pixel to a predicted modelled reflectance from a time series of observations. Finally, a localised object-based morphology check is completed for small cloud areas (< 200 hectares) to check that they do not represent valid land cover changes such as a paddock brightening or changes to a watercourse. This is done by checking the correspondence between cloud and cloud-shadow features, noting that a cloud-shadow should always have a corresponding cloud, but a cloud may not always have a cloud-shadow if it is obscured by other cloud or over a dark target such as water (figure A5.2.1).

[2] From French ‘Satellite pour l’Observation de la Terre’.

Figure A5.2.1 Classification steps in cloud-masking workflow



Panel A Panel B Panel C Panel D

Panel A shows the original Sentinel-2 image; panel B shows the result of the parallax cloud detection; panel C shows the classification of cloud (pink) and shadow (yellow); and panel D shows the result when full temporal processing is applied.

Once cloud-cleared, image strips are mosaicked together in a way that prioritises the most cloud-free strips and the imagery with the best (highest) sun angles. The 2021 mosaic of the mainland of New Zealand is composed of imagery from 84 distinct satellite passes selected from a total of 155 candidates (Harris et al., unpublished).

The imagery is then atmospherically and topographically corrected as documented in Dymond et al. (2001) and Shepherd and Dymond (2003). This standardisation process ensures that a 'colour' in the image corresponds directly to the type of land cover without being influenced by the variation in local illumination and view angle produced by topography. 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 its extensive areas of steep terrain.

Creating the first two land use maps: 1989 and 2007

Mapping approach – forest classes and Grassland with woody biomass

The 'woody' land use classes of pre-1990 natural and planted forest, post-1989 natural and planted forest and *Grassland with woody biomass* were delineated in the 1989 and 2007 land use maps 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. This basic land cover layer was created using a hierarchical binary classifier as described in Dymond and Shepherd (2004), providing a simple classification of vegetation into indigenous and exotic forest, narrow-leaved shrubland and herbaceous vegetation.

The same approach was used to classify vegetative land cover in the 1990 and 2008 image mosaics. These layers were then differenced from the 2001 reference layer to create a 1989 to 2001 potential woody change layer and a 2001 to 2007 potential woody change layer.

The potential woody change layers were visually checked to confirm the changes and then these were combined with the 2001 reference layer to create the 1989 and 2007 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 1989 versus 10 metres at 2007.

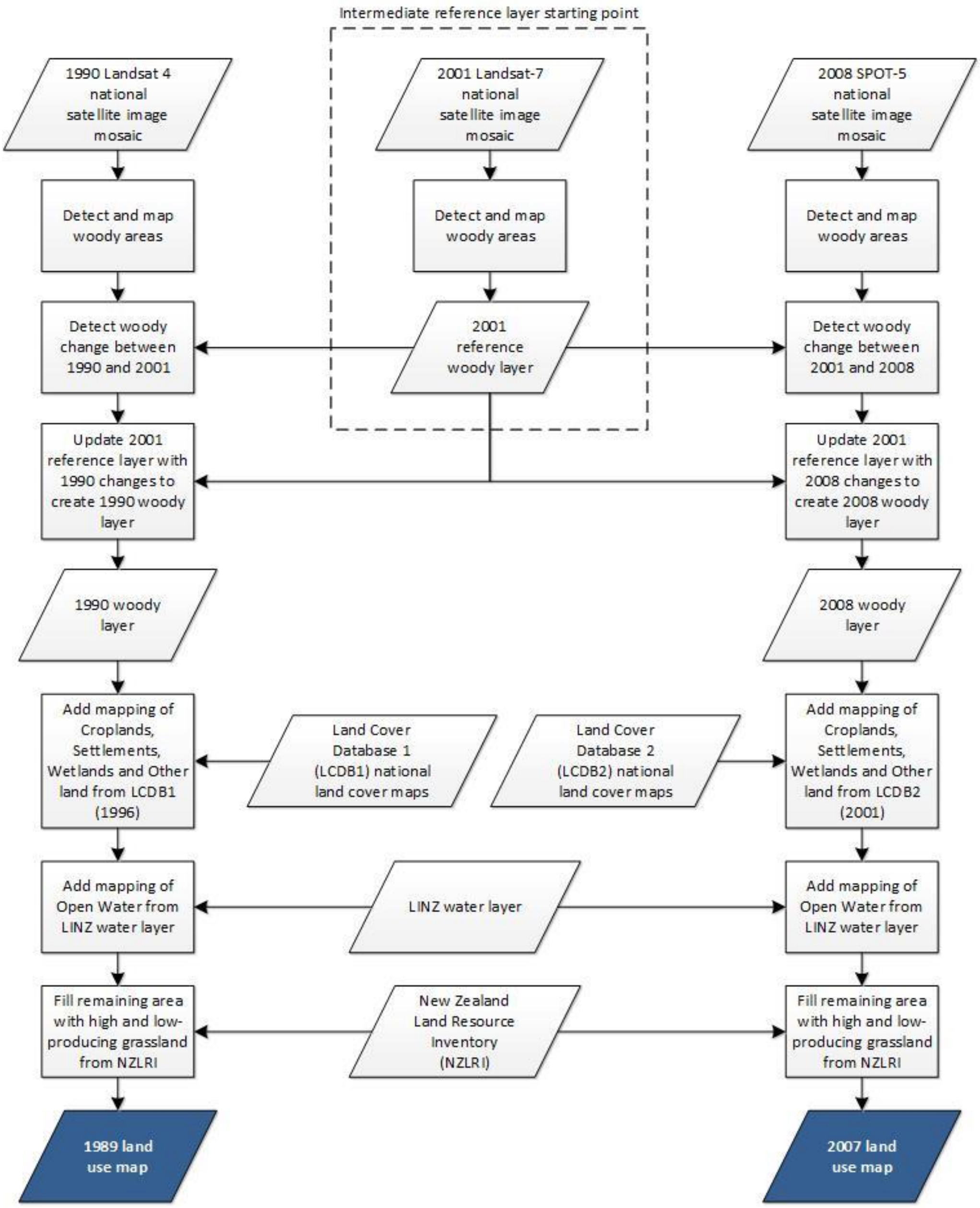
Area, proximity and temporal rules were used to convert these layers from woody land cover to woody land use classes, making allowances for unstocked areas within forest extents and areas of regenerating vegetation in a forest context. This process is described in Shepherd and Newsome (unpublished(a)).

Mapping approach – non-forest classes

To determine the spatial location of *Settlements*, *Wetlands*, *Croplands* and *Other land* as at 1989 and 2007, information from two Land Cover Databases, LCDB1 (1996) and LCDB2 (2001) (Thompson et al., 2004), and hydrological data from Land Information New Zealand (a government agency) were used (Shepherd and Newsome, unpublished(b)).

Areas of low and high producing grassland were mapped from the New Zealand Land Resource Inventory (NZLRI) (Eyles, 1977). 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. Use of a single data set to inform grassland mapping in both 1989 and 2007 meant that no change between low and high producing grassland classes was identified during initial mapping. This was subsequently updated during the 2016 mapping process as described below. Figure A5.2.2 illustrates this mapping process for the 1989 and 2007 land use maps.

Figure A5.2.2 New Zealand's land use mapping process for 1989 and 2007 land use maps



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

Quality control

An interpretation guide for automated and visual interpretation of satellite imagery was prepared and used to ensure a consistent basis for all land use classification decisions (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 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.

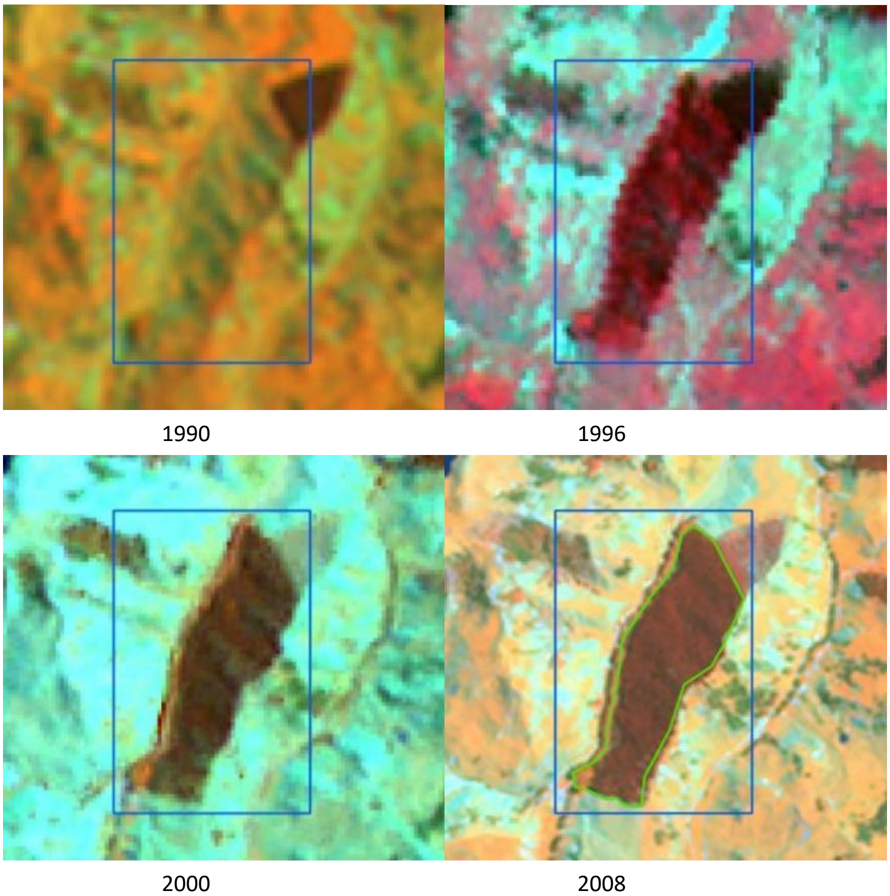
Owners of post-1989 forest may apply to lodge their forests within the NZ ETS to obtain credit for increases in carbon stock since 1 January 2008. Mapping received by Te Uru Rākau – New Zealand Forest Service for these applications is used to improve the Land Use and Carbon Analysis System (LUCAS) land 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 A5.2.3 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 A5.2.3	Identification of post-1989 forest in New Zealand**

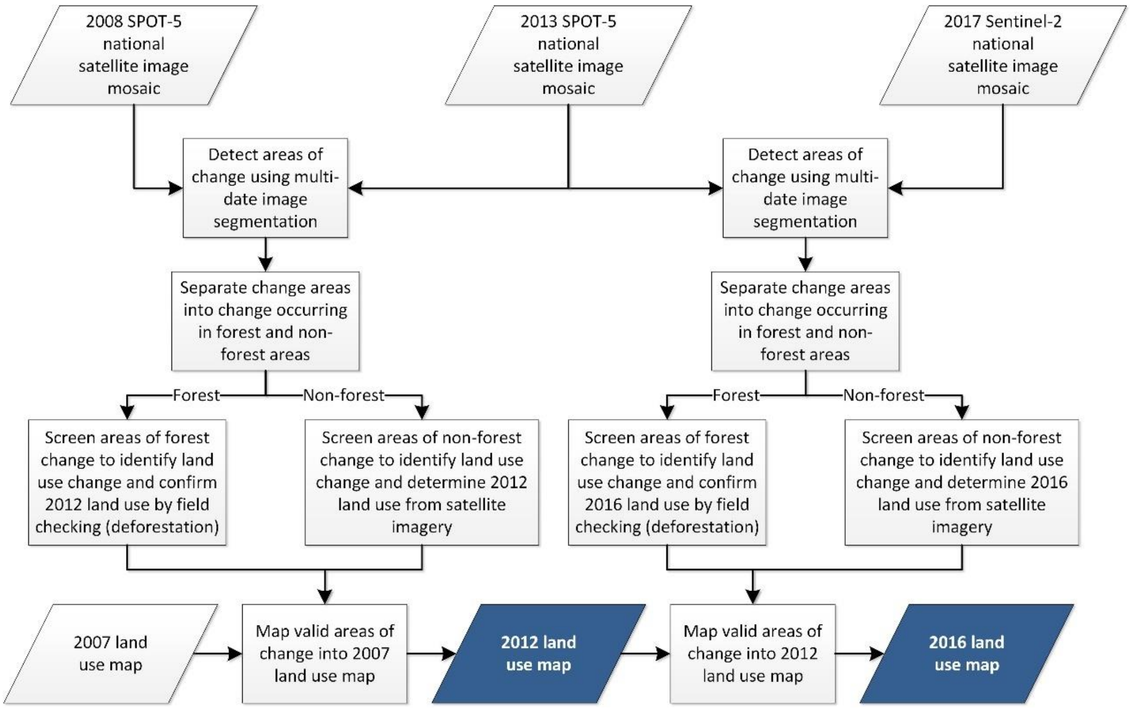


Images:	1990 Landsat 4 (top left) 1996 SPOT 2 (top right) 2000 Landsat 7 ETM+ (bottom left) 2008 SPOT 5 (bottom right)
Location:	2,017,800, 5,730,677 (NZTM)
1989 land use:	Low producing grassland
2007 land use:	Post-1989 forest
Explanation:	In the Landsat 1990 imagery acquired on 2 December 1990, there 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, 2013 and 2017) (Newsome et al., 2013, 2018). The 2012 map was created by using the 2007 map as a starting point and mapping in all the change detected between 2007 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 31 December 2016. Figure A5.2.4 illustrates this mapping process.

Figure A5.2.4 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 involved using a k-mean clustering algorithm to identify an initial set of unique spectral signatures across a multi-date image stack. This stack was made up of the red, near-infrared and short-wave infrared bands from the start and end dates of the change period. Clusters were grown from these initial points using an efficient iterative elimination process (Shepherd et al., 2019). This eventually yielded homogeneous patches of land cover or land-cover change of approximately 1 hectare in area, which is the minimum mapping unit of the LUCAS land use maps. 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 the other 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 2013 SPOT imagery and 2016 Sentinel-2 imagery, along with other imagery data sets as listed in table A5.2.2, to establish whether land-use change had occurred. Once change was confirmed, the area of change was delineated in the land use map.

Table A5.2.2 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 remapped at 2007, 2012 and 2016 using a data fusion technique described in Manderson et al. (2018).

Before the completion of 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 (see above), which was completed in the mid-1980s. No changes between low and high producing 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 new data fusion technique for grassland mapping 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 2007 maps to maintain time-series consistency. The 1989 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.[3] 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.

[3] '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.

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[4] 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.[5]
- 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.

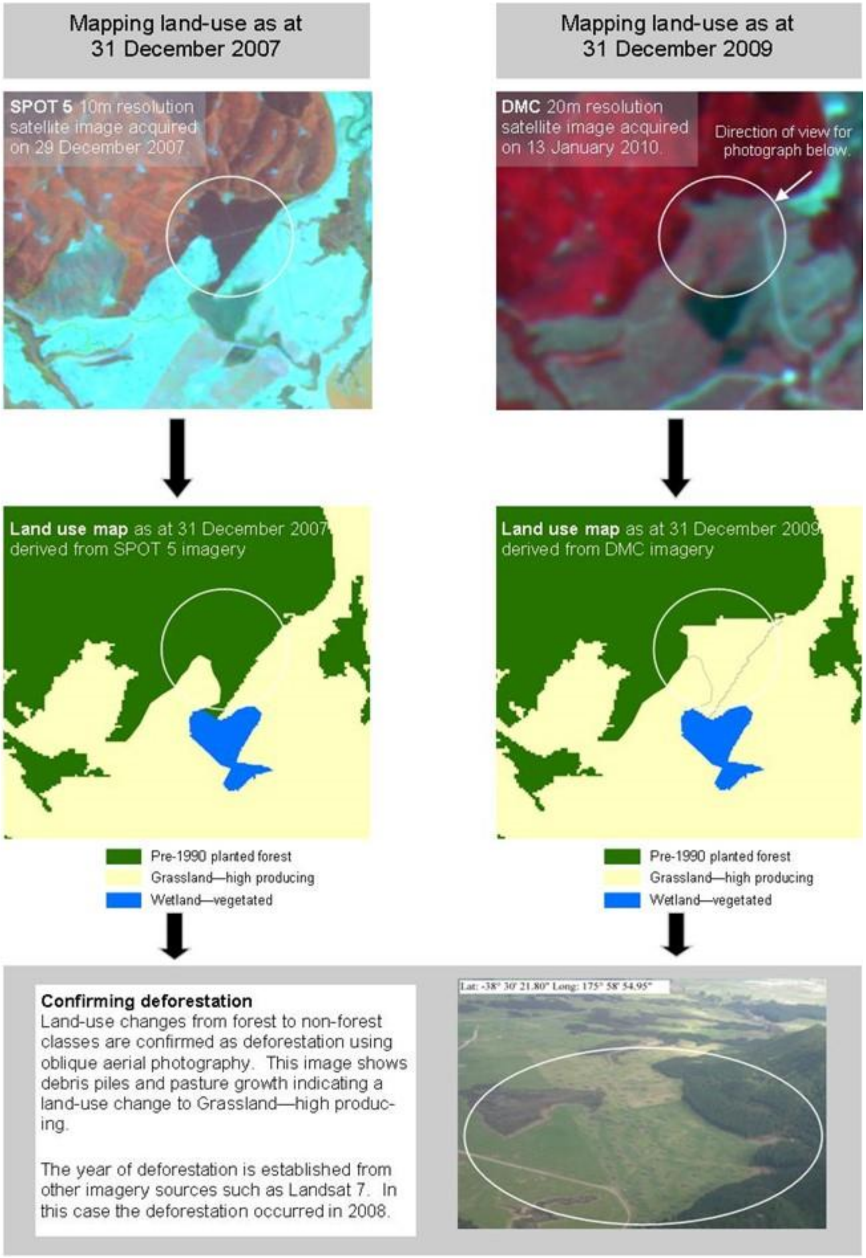
For each deforested area, further information was then recorded, such as the year in which the deforestation occurred. This was determined by examining the ancillary imagery data sets listed in table A5.2.2. Figure A5.2.5 shows the process of confirming deforestation and establishing the year in which 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.

4 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.

5 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 A5.2.5 **New Zealand's identification of deforestation**



Note: DMC = Disaster Monitoring Constellation.

Adding land use maps to the time series: 2020 land use map

The 2020 land use map was created by detecting change between the 2017 and 2021 satellite image mosaics. The 2016 map was used as the starting point and all the change detected between 2016 and 2020 was added to the map to create the 2020 land use map. The overall change detection process was the same as for the 2012 and 2016 land use maps outlined above and illustrated in figure A5.2.4. However, the mapping methodology introduced for the 2020 land use map was enhanced in the following ways.

Detection of missed forest using deep learning techniques

The land use mapping methodology described here relies on change detection to generate each new map. While this approach offers many advantages over independent map creation at each date, in terms of reducing error from random misclassification and increasing the accuracy of change mapping, it does have the drawback of not identifying persistent misclassifications in unchanged parts of the map. The original land use mapping was effectively based off a basic land cover layer derived from 2001 Landsat 7 imagery (see above). Any area where no change has subsequently been detected has not been remapped since that date. This means that these areas have not benefited from the improvements to satellite imagery and mapping methods that have occurred since the development of the 1989 and 2007 maps.

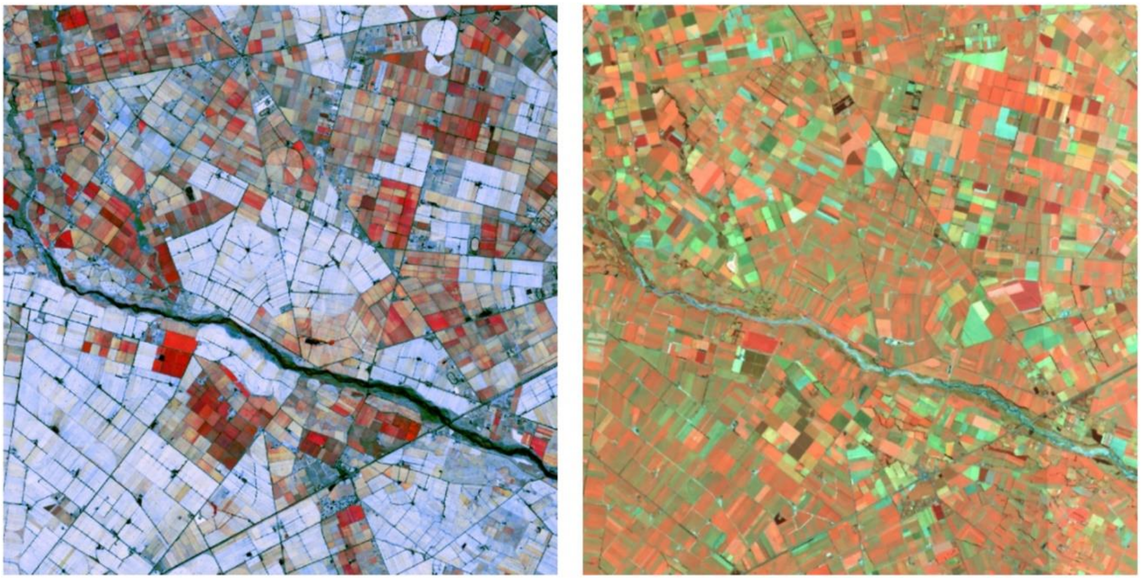
As part of the 2020 land use mapping process, an assessment was made of the potential of deep learning mapping methods to derive independent 2016 and 2020 maps of land cover that related to the LUM classes. These land cover classes included indigenous and exotic forests. The deep learning model was trained on a land cover derivative of the 2016 LUM and then used to predict 2016 land cover map. When trained on 50 per cent of the map, it predicted the remaining 50 per cent with an overall pixel accuracy of 89 per cent (Martin et al., unpublished). There was significant variability in the accuracy of the mapping of individual land covers; however, the prediction for exotic forest highlighted several areas where this cover had previously been missed in the land use mapping. These areas had generally been present since 1990. As a result, approximately 8,600 hectares of missed exotic forest were added to all of the maps in the time series (Martin et al., unpublished).

Updates to the mapping of annual cropland using multi-temporal analysis

The mapping of annual cropland from a single summer image mosaic is problematic as an identified cultivated paddock can be either undergoing pasture renewal or being prepared for sowing in a crop. It could therefore be in a grassland or a cropland land use.

To assist with discriminating between these two possible land uses, the Normalised Difference Vegetation Index (NDVI) was calculated for a time series of Sentinel-2 imagery acquired between 2016 and 2020. Areas that were consistently vegetated were considered to be more likely to be grassland, whereas areas that were often cultivated were more likely to be cropland (Harris et al., unpublished). Figure A5.2.6(a) shows a representation of this multi-temporal analysis with areas of continuous vegetation shown in light blue and areas undergoing regular cultivation in red. The Sentinel-2 summer image of the same area is shown in figure A5.2.6(b).

Figure A5.2.6 Identification of annual cropland through multi-temporal analysis



Panel A Panel B

Panel A shows a map of Canterbury highlighting vegetation patterns indicative of rotational cropping (red) and permanent pasture (light blue) using ratios of positive NDVI images; Panel B shows a topographically flattened summer mosaic of the same area.

Identification of grassland change using property valuation land use classification

The method for identification of change between low and high producing grassland over the period 2017–20 followed the data fusion approach developed previously for the 2016 land use map; however, it was simplified to include only those source data sets that had changed over the period – the property valuation land use classification and the protected area data set. These data sets were used to infer areas that had changed from low to high producing grassland or the reverse (Harris et al., unpublished).

Field checking of forest loss using machine learning techniques

Areas of forest loss (destocking) were first detected through automated change detection in annual national Sentinel-2 satellite imagery mosaics. These areas of destocking, occurring between 2017 and 2020, were field checked using high resolution (20–30 cm) vertical aerial imagery to determine which areas had undergone land-use change (deforestation).

To assist with the task of visual interpretation of the aerial imagery acquired, machine learning techniques were developed to identify 13 distinct land cover classes in destocked areas (Lynker Analytics Consortium, 2020, 2022). The 13 land cover classes identified are listed in table A5.2.3. Two examples of this land cover mapping are shown in figure A5.2.7. The overall model accuracy was 76 per cent, making the model a useful tool in the deforestation mapping workflow but not accurate enough to use without manual checking.

Table A5.2.3 Land cover classes within areas of forest loss identified by machine learning techniques

Land cover	Description
Built forest	Access tracks and cut sites
Built other	Buildings and pavements
Cutover	Tree stumps and branches left on site following clear-fell harvest activity
Exotic regenerating forest	Wilding pine trees that have self-seeded
Grass/pasture	Pasture areas with an even surface suitable for grazing
Mature exotic forest	Closed canopy exotic trees including plantation species such Pinus radiata and Douglas fir and other exotic trees such as eucalypts sometimes used as edge protection for plantation forests
Mature native forest	Mixed indigenous forest often found in gullies within plantation forest
Natural other	Gravel, scree, riverbank
Natural regenerating forest	Regenerating indigenous shrubland that has the potential to reach forest definition
Other	
Plantation seedlings	Tree seedlings planted with regular spacing
Shadow	Dark area of image where land cover cannot be determined due to terrain or cloud-shadow
Water	Pond, lake, river or ocean

A multi-criteria analysis of the land cover areas within each destocked area (or 'target') was used to infer the current land use. The objective of this process was to identify targets with land cover combinations that were consistent with deforestation, and targets with land covers that were more consistent with harvest and replant activity. These criteria, which were applied in descending order, are shown in table A5.2.4.

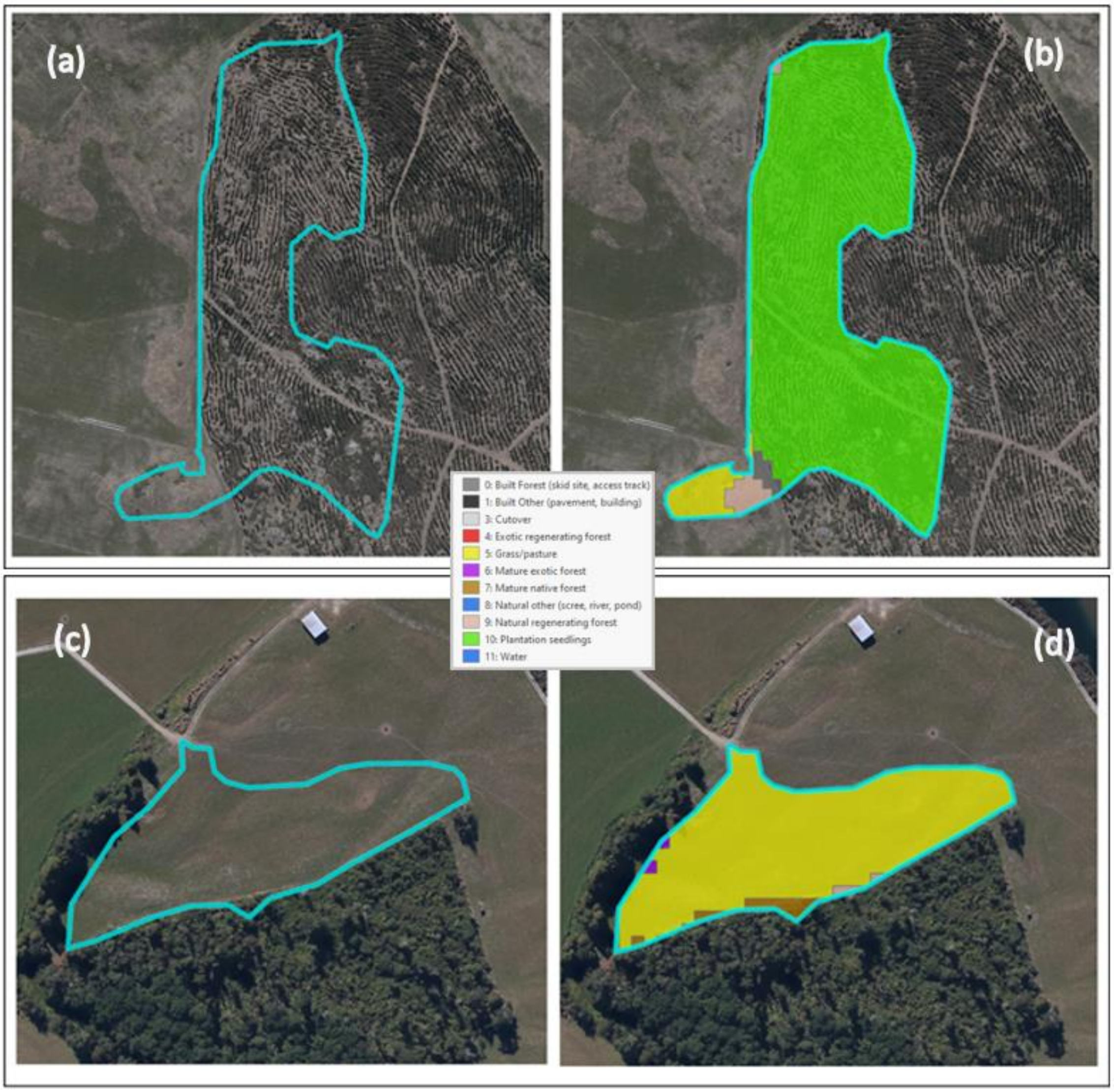
Table A5.2.4 Criteria used to determine deforestation status of each area of destocking based on the proportions of different types of land cover identified by machine learning process

Step	Criteria (excluding areas of Shadow, Mature Native, Mature Exotic, Built Forest)	Deforestation / replant status
1	Built Other + Pasture + Crop + Horticulture > 80%	Fully deforested
2	Built Other + Pasture + Crop + Horticulture > 1 ha	Partially deforested
3	Plantation Seedlings > 70%	Fully replanted
4	Plantation Seedlings > 1 ha OR > 30%	Partially replanted
5	Exotic Regen OR Cutover > 1 ha or > 30%	Not replanted
6	(Re)-include Mature Exotic > 1 ha	Still forest
7	Natural Damage + Natural Other > 1 ha	Natural adverse event
8	All other	Unknown

This approach allowed all areas of potential deforestation greater than 1 hectare in area to be identified for further manual checking and accurate delineation. All other targets were also rapidly screened to identify any misclassifications and to check the areas with a deforestation or replant status of 'Unknown'.

Finally, all areas of identified deforestation were added to the 2020 land use map along with the year of forest loss. This enables spatially explicit reporting of deforestation by year.

Figure A5.2.7 Land cover mapping over forest loss areas using machine learning techniques



Note: (a) and (c) show aerial imagery of areas of previously identified forest loss; (b) shows the land cover classification for the forest loss area in (a), with a dominant land cover of plantation seedlings equating to a status of fully replanted; (d) shows a land cover classification for the forest loss area in (c), with a dominant land cover of grass/pasture equating to a status of fully deforested.

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

During the mapping process, the 1989, 2007, 2012, 2016 and 2020 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 1989 and 2007 land use maps included checking around 28,000 randomly selected points in areas mapped as *Forest land* 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 1989 and 2007 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 2007 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.

Quality-control checking for the 2020 land use map was done thematically throughout the land use mapping process as described in Harris et al. (unpublished) and by the Ministry for the Environment at the completion of each major milestone. These checks included:

- comparison of change areas before and after each mapping update
- visual checks to identify gross anomalies and detailed linework issues
- automated attribute checks of individual polygons to identify inconsistent combinations of land uses throughout the time series
- topology checks to identify gaps and overlaps in the map data.

Each mapping improvement activity carried out on the 1989, 2007, 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.[6]

[6] 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 another 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.

A5.2.2 Annual land-use change

Annual land-use change areas are interpolated and extrapolated from the five national land use maps using a number of supporting data sets to inform the trends occurring between the wall-to-wall mapping dates of 1989, 2007, 2012, 2016 and 2020.

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 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC, 2006b).

The approach to calculating the pre-1990 planted forest new planting time series (1962 to 1989) has been improved for the 2024 submission and is now based on a five-year moving average of the difference in standing area and new planting area from the National Exotic Forest Description (NEFD), instead of a one-year average of these two NEFD data sets (i.e., difference between new planting area and standing area). This is to smooth out the year-to-year fluctuations, and to adjust for an outlier identified by Hunter and McNeill (unpublished). The net effect of this is that the forest age profile as at the most recent reporting year more closely resembles the NEFD forest age profile.

Annual land-use changes from 1990 to 2007

Annual land-use changes from 1990 to 2007 are interpolated between the 1989 and 2007 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, 2006b).

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

- Deforestation trends between 1990 and 31 December 2007 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 NEFD (Ministry for Primary Industries, 2023a).
- Afforestation trends for post-1989 natural forest are based on the plot analysis in Paul et al. (unpublished(a)). The age of vegetation on plots was used to estimate the year when 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 2020

Annual land-use changes from 2008 to 2020 are generally linearly interpolated between the 2007, 2012, 2016 and 2020 land use maps. The only exceptions to this are:

- deforestation occurring between 2008 and 2020, which is mapped annually
- afforestation, which uses a mixture of mapped and surveyed data as detailed in table A5.2.5. This is because not all new planting will have been detected in satellite imagery and mapped into the 2020 map yet. New planting can take up to four years to be visible in satellite imagery; therefore, afforestation mapping up to 2020 will not be finalised until the 2025 land use map is produced.

Table A5.2.5 Methods used to estimate afforestation total area and trends between 2008 and 2020

	Reporting years: 2008–16		Reporting years: 2017–20	
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 2016	Based on new planting data from national survey (National Exotic Forest Description)	Based on new planting data from national survey (National Exotic Forest Description)	Based on new planting data from national survey (National Exotic Forest Description)
Post-1989 natural forest, except wilding sub-class	Based on afforestation mapped between 2008 and 2016	Linear interpolation	Based on mapping from national forestry schemes including the NZ ETS	Based on mapping from national forestry schemes including the NZ ETS
Post-1989 natural forest, wilding sub-class	Based on afforestation mapped between 2008 and 2016	Linear interpolation	Total afforestation calculated as four times the average annual deforestation mapped between 2017 to 2020	Linear interpolation

Note: NZ ETS = New Zealand Emissions Trading Scheme.

Estimating land-use change for 2021 and 2022

Activity data for the two most recent years of this inventory, from 2021 to 2022, have been estimated from a survey for afforestation (Ministry for Primary Industries, 2023a) and extrapolated from the most recent mapping for all other land-use changes.

Deforestation

The total estimated area of deforestation of planted forest occurring during 2021 and 2022 has been extrapolated from the total annual mapped planted forest deforestation over the period 2014 to 2020. Over this period there has been a downward trend in both the total annual planted forest deforestation and the annual pre-1990 planted forest deforestation. This downward trend in deforestation is in response to the increasing domestic price of carbon and therefore increased cost associated with deforestation.

In particular, deforestation of pre-1990 planted forest has decreased significantly, as noted in the Afforestation and Deforestation Intentions Survey 2022 (Manley, 2023). To more accurately estimate the proportions of pre-1990 and post-1989 planted forest deforestation occurring during 2021 and 2022, the pre-1990 planted forest deforestation component has been limited to a scaled version of the Manley survey values, recognising that the land use maps have broader coverage than the survey. The scaling factor is calculated by comparing mapped pre-1990 planted forest deforestation and survey values for the 2017 to 2020 period. The average annual scaling factor is then applied to the survey estimate for 2021 and 2022 to obtain the pre-1990 planted forest deforestation estimates for those years. The post-1989 planted forest deforestation estimates for 2021 and 2022 are then calculated as the difference between the total estimated planted forest deforestation and the pre-1990 planted forest deforestation for each year.

The estimated area of deforestation of pre-1990 natural forest and post-1989 natural forest occurring in 2021 and 2022 has been calculated as the average of the three previous mapped years. Natural forest deforestation has occurred at relatively low levels in recent years but there is not sufficient evidence of a downward trend in the data to justify using the extrapolation approach employed for the planted forest classes. Natural forest deforestation is not subject to the same carbon price liabilities as planted forest deforestation although there are other environmental constraints to clearing this type of forest.

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 2017 to 2020.

Afforestation

The annual area of afforestation of post-1989 planted forest for 2021 and 2022 is based on estimates from the NEFD (Ministry for Primary Industries, 2023a). The annual area of afforestation of post-1989 natural forest for 2021 is estimated from the Ministry for Primary Industries afforestation scheme data. The area of post-1989 natural afforestation for 2022 is estimated from the Afforestation and Deforestation Intentions Survey for 2022 by taking the total area of ‘natural reversion’ and ‘indigenous tall planted’ (Manley, 2023).

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 2022.

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 2021 to 2022 have been linearly extrapolated from the changes mapped between 2016 and 2020.

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, 2006c).

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. The impact of the 2020 land use map on 2021 emissions has also been calculated – an increase of approximately 54 kilotonnes carbon dioxide equivalent (kt CO_2-e). The impact of other improvements implemented in the 2024 submission has been excluded from this calculation.

A5.2.3 Annual land-use change summary

This section contains a summary of the annual land-use change from 1990 to 2022 (table A5.2.6).

Table A5.2.6 Annual land-use changes (units hectares)

Original land use		Forest land				Cropland		Grassland			Wetlands			
Destination land use	**Year**	**Pre-1990 natural forest**	**Pre-1990 planted forest**	**Post-1989 planted forest**	**Post-1989 natural forest**	**Annual**	**Perennial**	**High producing**	**Low producing**	**With woody biomass**	**Open water**	**Vegetated**	**Settlements**	**Other land**
Pre-1990 natural forest	1990	–	81	–	–	–	–	–	–	–	–	–	–	–
	1991	–	81	–	–	–	–	–	–	–	–	–	–	–
	1992	–	81	–	–	–	–	–	–	–	–	–	–	–
	1993	–	81	–	–	–	–	–	–	–	–	–	–	–
	1994	–	81	–	–	–	–	–	–	–	–	–	–	–
	1995	–	81	–	–	–	–	–	–	–	–	–	–	–
	1996	–	81	–	–	–	–	–	–	–	–	–	–	–
	1997	–	81	–	–	–	–	–	–	–	–	–	–	–
	1998	–	81	–	–	–	–	–	–	–	–	–	–	–
	1999	–	81	–	–	–	–	–	–	–	–	–	–	–
	2000	–	81	–	–	–	–	–	–	–	–	–	–	–
	2001	–	81	–	–	–	–	–	–	–	–	–	–	–
	2002	–	81	–	–	–	–	–	–	–	–	–	–	–
	2003	–	81	–	–	–	–	–	–	–	–	–	–	–
	2004	–	81	–	–	–	–	–	–	–	–	–	–	–
	2005	–	81	–	–	–	–	–	–	–	–	–	–	–
	2006	–	81	–	–	–	–	–	–	–	–	–	–	–
	2007	–	81	–	–	–	–	–	–	–	–	–	–	–
	2008	–	365	–	–	–	–	5	4	5	–	–	–	–
	2009	–	365	–	–	–	–	5	4	5	–	–	–	–
	2010	–	365	–	–	–	–	5	4	5	–	–	–	–

Original land use		Forest land				Cropland		Grassland			Wetlands			
Destination land use	Year	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 planted forest	Post-1989 natural forest	Annual	Perennial	High producing	Low producing	With woody biomass	Open water	Vegetated	Settlements	Other land
	2011	–	365	–	–	–	–	5	4	5	–	–	–	–
	2012	–	365	–	–	–	–	5	4	12	–	–	–	–
	2013	–	83	–	–	–	–	5	18	60				
	2014	–	83	–	–	–	–	5	3	60	–	–	–	–
	2015	–	83	–	–	–	–	5	3	60	–	–	–	–
	2016	–	83	–	–	–	–	5	3	60	–	–	–	–
	2017	–	–	–	–	–	–	3	7	0	–	–	–	–
	2018	–	–	–	–	–	–	3	7	–	–	–	–	–
	2019	–	–	–	–	–	–	3	7	–	–	–	–	–
	2020	–	–	–	–	–	–	3	7	–	–	–	–	–
	2021	–	–	–	–	–	–	–	–	–	–	–	–	–
	2022	–	–	–	–	–	–	–	–	–	–	–	–	–
Pre-1990 planted forest	1990	1,401	–	–	–	–	–	–	–	–	–	–	–	–
	1991	1,401	–	–	–	–	–	–	–	–	–	–	–	–
	1992	1,401	–	–	–	–	–	–	–	–	–	–	–	–
	1993	1,401	–	–	–	–	–	–	–	–	–	–	–	–
	1994	1,401	–	–	–	–	–	–	–	–	–	–	–	–
	1995	1,401	–	–	–	–	–	–	–	–	–	–	–	–
	1996	1,401	–	–	–	–	–	–	–	–	–	–	–	–
	1997	1,401	–	–	–	–	–	–	–	–	–	–	–	–
	1998	1,401	–	–	–	–	–	–	–	–	–	–	–	–
	1999	1,401	–	–	–	–	–	–	–	–	–	–	–	–
	2000	1,401	–	–	–	–	–	–	–	–	–	–	–	–
	2001	1,401	–	–	–	–	–	–	–	–	–	–	–	–
	2002	1,401	–	–	–	–	–	–	–	–	–	–	–	–
	2003	1,408	–	–	–	–	–	–	–	–	–	–	–	–

Original land use		Forest land				Cropland		Grassland			Wetlands			
Destination land use	Year	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 planted forest	Post-1989 natural forest	Annual	Perennial	High producing	Low producing	With woody biomass	Open water	Vegetated	Settlements	Other land
	2004	1,401	–	–	–	–	–	–	–	–	–	–	–	–
	2005	1,401	–	–	–	–	–	–	–	–	–	–	–	–
	2006	1,401	–	–	–	–	–	–	–	–	–	–	–	–
	2007	1,401	–	–	–	–	–	–	–	–	–	–	–	–
	2008	147	–	–	–	–	–	17	28	70	–	1		1
	2009	147	–	–	–	–	–	17	28	70	–	1		1
	2010	147	–	–	–	–	–	17	28	70	–	1		1
	2011	147	–	–	–	–	–	21	28	70	–	1		1
	2012	147	–	–	–	–	–	17	28	70	–	1		1
	2013	5	–	–	–	–	–	33	86	139	–	–	–	–
	2014	5	–	–	–	–	–	29	93	92	–	–	–	–
	2015	5	–	–	–	–	–	29	95	88	–	–	–	–
	2016	5	–	–	–	–	–	29	94	92	–	–	–	–
	2017	64	–	–	–	–	–	18	57	49	–	–	–	–
	2018	64	–	–	–	–	–	56	82	159	–			0
	2019	64	–	–	–	–	–	129	133	54	–	–	–	–
	2020	64	–	–	–	–	–	48	168	44	–	–	–	–
	2021	64	–	–	–	–	–	–	–	–	–	–	–	–
	2022	64	–	–	–	–	–	–	–	–	–	–	–	–
Post-1989 planted forest	1990	–	–	–	–	10	0	2,713	8,005	2,886	1	28	0	66
	1991	–	–	–	–	9	0	2,645	7,811	2,813	1	28	0	64
	1992	–	–	–	–	36	1	8,640	25,486	9,184	5	90	1	210
	1993	–	–	–	–	37	1	10,596	31,230	11,262	6	111	1	259
	1994	–	–	–	–	60	2	16,897	49,765	17,979	9	177	2	411
	1995	–	–	–	–	45	1	12,690	37,548	13,519	7	133	1	309
	1996	–	–	–	–	51	1	14,358	42,593	15,292	8	150	2	350

Original land use		Forest land				Cropland		Grassland			Wetlands			
Destination land use	Year	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 planted forest	Post-1989 natural forest	Annual	Perennial	High producing	Low producing	With woody biomass	Open water	Vegetated	Settlements	Other land
	1997	–	–	–	–	39	1	10,972	32,379	11,666	6	115	1	267
	1998	–	–	–	–	31	1	8,801	25,988	9,357	5	92	1	214
	1999	–	–	–	–	24	1	6,883	20,302	7,307	4	72	1	167
	2000	–	–	–	–	20	1	5,770	17,174	6,138	3	60	1	141
	2001	–	–	–	–	18	1	5,174	15,257	5,506	3	54	1	126
	2002	–	–	–	–	13	0	3,795	11,199	4,037	2	40	0	92
	2003	–	–	–	–	12	0	3,417	10,082	3,635	2	36	0	83
	2004	–	–	–	–	6	0	1,820	5,370	1,936	1	19	0	44
	2005	–	–	–	–	4	0	1,030	3,068	1,096	1	11	0	25
	2006	–	–	–	–	2	0	446	1,317	475	0	5	0	11
	2007	–	–	–	–	1	0	412	1,216	438	0	4	0	10
	2008	–	–	–	–	1	–	588	1,708	466	–	2	0	12
	2009	–	–	–	–	2	–	1,330	3,866	1,037	–	5	0	14
	2010	–	–	–	–	3	–	1,856	5,394	1,447	–	8	0	19
	2011	–	–	–	–	6	–	3,712	10,788	2,894	–	15	0	38
	2012	–	–	–	–	6	–	3,557	10,338	2,774	–	15	0	37
	2013	–	–	–	–	–	–	1,150	4,060	1,048	–	2	–	1
	2014	–	–	–	–	–	–	866	3,090	768	–	2	–	1
	2015	–	–	–	–	–	–	866	3,090	768	–	2	–	1
	2016	–	–	–	–	–	–	412	2,030	378	–	1	–	0
	2017	–	–	–	–	11	–	2,337	3,314	870	–	–	0	–
	2018	–	–	–	–	14	–	2,734	4,379	516	–	–	0	–
	2019	–	–	–	–	48	–	9,161	10,666	1,578	–	–	0	–
	2020	–	–	–	–	88	–	16,788	19,020	2,673	–	–	0	–
	2021	–	–	–	–	118	–	22,396	25,057	3,550	–	–	0	–
	2022	–	–	–	–	184	–	34,856	38,998	5,525	–	–	0	–

Original land use		Forest land				Cropland		Grassland			Wetlands			
Destination land use	Year	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 planted forest	Post-1989 natural forest	Annual	Perennial	High producing	Low producing	With woody biomass	Open water	Vegetated	Settlements	Other land
Post-1989 natural forest	1990	–	–	–	–	0	0	40	439	491	–	0	0	11
	1991	–	–	–	–	0	0	47	512	573	–	0	0	12
	1992	–	–	–	–	0	0	54	585	655	–	0	0	14
	1993	–	–	–	–	0	0	47	512	573	–	0	0	12
	1994	–	–	–	–	0	0	40	439	491	–	0	0	11
	1995	–	–	–	–	0	0	34	366	409	–	0	0	9
	1996	–	–	–	–	0	0	34	366	409	–	0	0	9
	1997	–	–	–	–	0	0	107	1,173	1,310	–	0	0	28
	1998	–	–	–	–	0	0	121	1,317	1,474	–	0	0	32
	1999	–	–	–	–	0	0	134	1,464	1,638	–	0	0	35
	2000	–	–	–	–	0	0	168	1,830	2,047	–	0	0	44
	2001	–	–	–	–	0	0	201	2,195	2,457	–	0	0	53
	2002	–	–	–	–	0	0	161	1,756	1,965	–	0	0	42
	2003	–	–	–	–	0	0	181	1,976	2,211	–	0	0	48
	2004	–	–	–	–	0	0	241	2,634	2,948	–	0	0	64
	2005	–	–	–	–	0	0	282	3,074	3,439	–	0	0	74
	2006	–	–	–	–	0	0	322	3,513	3,930	–	0	0	85
	2007	–	–	–	–	0	0	302	3,293	3,685	–	0	0	80
	2008	–	–	–	–	–	–	32	653	1,074	–	–	3	3
	2009	–	–	–	–	–	–	32	653	1,031	–	–	3	3
	2010	–	–	–	–	–	–	32	653	1,031	–	–	3	3
	2011	–	–	–	–	–	–	32	653	1,031	–	–	3	3
	2012	–	–	–	–	–	–	32	653	1,031	–	–	3	3
	2013	–	–	–	–	–	–	97	1,482	539	–	–	–	2
	2014	–	–	–	–	–	–	97	1,482	535	–	–	–	2
	2015	–	–	–	–	–	–	97	1,482	535	–	–	–	2

Original land use		Forest land				Cropland		Grassland			Wetlands			
Destination land use	Year	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 planted forest	Post-1989 natural forest	Annual	Perennial	High producing	Low producing	With woody biomass	Open water	Vegetated	Settlements	Other land
	2016	–	–	–	–	–	–	116	1,525	535	–	–	–	2
	2017	–	–	–	–	–	–	1,711	2,128	953	–	–	–	–
	2018	–	–	–	–	–	–	1,500	1,866	743	–	–	–	–
	2019	–	–	–	–	–	–	1,914	2,381	948	–	–	–	–
	2020	–	–	–	–	–	–	1,792	2,229	888	–	–	–	–
	2021	–	–	–	–	–	–	1,441	1,792	714	–	–	–	–
	2022	–	–	–	–	–	–	2,510	3,121	1,243	–	–	–	–
Annual cropland	1990	1	–	–	–	–	83	1,263	37	6	–	1	–	–
	1991	1	–	–	–	–	83	1,263	37	6	–	1	–	–
	1992	1	–	–	–	–	83	1,263	37	6	–	1	–	–
	1993	1	–	–	–	–	83	1,263	37	6	–	1	–	–
	1994	1	–	–	–	–	83	1,263	37	6	–	1	–	–
	1995	1	–	–	–	–	83	1,263	37	6	–	1	–	–
	1996	1	–	–	–	–	83	1,263	37	6	–	1	–	–
	1997	1	–	–	–	–	83	1,263	37	6	–	1	–	–
	1998	1	–	–	–	–	83	1,263	37	6	–	1	–	–
	1999	1	–	–	–	–	83	1,263	37	6	–	1	–	–
	2000	1	9	–	–	–	83	1,263	37	6	–	1	–	–
	2001	1	8	–	–	–	83	1,263	37	6	–	1	–	–
	2002	1	6	3	–	–	83	1,263	37	6	–	1	–	–
	2003	1	12	10	–	–	83	1,263	37	6	–	1	–	–
	2004	1	28	9	–	–	83	1,263	37	6	–	1	–	–
	2005	1	58	10	–	–	83	1,263	37	6	–	1	–	–
	2006	1	73	9	–	–	83	1,263	37	6	–	1	–	–
	2007	1	97	21	–	–	83	1,263	37	6	–	1	–	–
	2008	–	33	7	–	–	181	30	11	9	0	–	0	–

Original land use		Forest land				Cropland		Grassland			Wetlands			
Destination land use	Year	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 planted forest	Post-1989 natural forest	Annual	Perennial	High producing	Low producing	With woody biomass	Open water	Vegetated	Settlements	Other land
	2009	–	3	2	–	–	181	30	11	9	0	–	0	–
	2010	3	10	37	–	–	181	30	11	9	0	–	0	–
	2011	–	14	20	–	–	181	30	11	9	0	–	0	–
	2012	–	6	14	–	–	181	30	11	9	0	–	0	–
	2013	3	93	58	–	–	–	6	4	2	–	–	–	–
	2014	6	29	32	–	–	–	6	4	2	–	–	–	–
	2015	7	5	3	–	–	–	6	4	2	–	–	–	–
	2016	–	10	13	–	–	–	6	4	2	–	–	–	–
	2017	–	4	16	–	–	–	16,304	215	55	–	–	–	–
	2018	–	2	6	–	–	–	16,304	215	55	–	–	–	–
	2019	–	12	14	–	–	–	16,312	216	55	–	–	–	–
	2020	–	3	9	–	–	–	16,295	215	55	–	–	–	–
	2021	–	–	–	–	–	–	14,268	214	50	–	–	–	–
	2022	–	–	–	–	–	–	14,268	214	50	–	–	–	–
Perennial cropland	1990	3	–	–	–	332	–	1,639	157	21	0	0	0	–
	1991	3	–	–	–	332	–	1,639	157	21	0	0	0	–
	1992	3	–	–	–	332	–	1,639	157	21	0	0	0	–
	1993	3	–	–	–	332	–	1,639	157	21	0	0	0	–
	1994	3	–	–	–	332	–	1,639	157	21	0	0	0	–
	1995	3	–	–	–	332	–	1,639	157	21	0	0	0	–
	1996	3	–	–	–	332	–	1,639	157	21	0	0	0	–
	1997	3	–	–	–	332	–	1,639	157	21	0	0	0	–
	1998	3	–	–	–	332	–	1,639	157	21	0	0	0	–
	1999	3	–	–	–	332	–	1,639	157	21	0	0	0	–
	2000	3	9	–	–	332	–	1,639	157	21	0	0	0	–
	2001	3	9	–	–	332	–	1,639	157	21	0	0	0	–

Original land use		Forest land				Cropland		Grassland			Wetlands			
Destination land use	Year	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 planted forest	Post-1989 natural forest	Annual	Perennial	High producing	Low producing	With woody biomass	Open water	Vegetated	Settlements	Other land
	2002	3	6	4	–	332	–	1,639	157	21	0	0	0	–
	2003	3	13	13	–	332	–	1,639	157	21	0	0	0	–
	2004	3	31	12	–	332	–	1,639	157	21	0	0	0	–
	2005	3	63	13	–	332	–	1,639	157	21	0	0	0	–
	2006	3	80	12	–	332	–	1,639	157	21	0	0	0	–
	2007	3	106	28	–	332	–	1,639	157	21	0	0	0	–
	2008	–	–	–	–	122	–	444	48	2	–	–	–	–
	2009	–	8	2		122	–	444	48	2	–	–	–	–
	2010	–	–	–	–	122	–	444	48	2	–	–	–	–
	2011	–	–	–	–	130	–	444	48	2	–	–	–	–
	2012	–	–	–	–	122	–	444	48	2	–	–	–	–
	2013	–	–	–	–	224	–	314	–	4	–	–	–	1
	2014	–	5	–	–	224	–	314	–	4	–	–	–	1
	2015	–		–	–	224	–	315	–	4	–	–	–	1
	2016	–	3	–	–	224	–	314	–	7	–	–	–	1
	2017	–	–	–	–	163	–	121	2	1	–	–	–	–
	2018	–	6	5	–	146	–	143	4	1	–	–	–	–
	2019	2	48	6	–	146	–	123	2	1	–	–	–	–
	2020	–	18	–	–	146	–	121	2	1	–	–	–	–
	2021	–	–	–	–	100	–	110	2	1	–	–	–	–
	2022	–	–	–	–	100	–	110	2	1	–	–	–	–
Grassland – high producing	1990	568	–	–	–	101	185	–	55,081	1,173	6	242	0	6
	1991	568	–	–	–	101	185	–	55,081	1,173	6	242	0	6
	1992	568	–	–	–	101	185	–	55,081	1,173	6	242	0	6
	1993	568	–	–	–	101	185	–	55,081	1,173	6	242	0	6
	1994	568	–	–	–	101	185	–	55,081	1,173	6	242	0	6

Original land use		Forest land				Cropland		Grassland			Wetlands			
Destination land use	Year	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 planted forest	Post-1989 natural forest	Annual	Perennial	High producing	Low producing	With woody biomass	Open water	Vegetated	Settlements	Other land
	1995	568	–	–	–	101	185	–	55,081	1,173	6	242	0	6
	1996	568	–	–	–	101	185	–	55,081	1,173	6	242	0	6
	1997	568	–	–	–	101	185	–	55,081	1,173	6	242	0	6
	1998	568	–	–	–	101	185	–	55,081	1,173	6	242	0	6
	1999	568	–	–	–	101	185	–	55,081	1,173	6	242	0	6
	2000	568	1,512	–	–	101	185	–	55,081	1,173	6	242	0	6
	2001	568	1,450	–	–	101	185	–	55,081	1,173	6	242	0	6
	2002	568	980	637	–	101	185	–	55,081	1,173	6	242	0	6
	2003	568	2,155	2,008	–	101	185	–	55,081	1,173	6	242	0	6
	2004	568	4,968	1,845	–	101	185	–	55,081	1,173	6	242	0	6
	2005	568	10,190	2,099	–	101	185	–	55,081	1,173	6	242	0	6
	2006	568	12,825	1,799	–	101	185	–	55,081	1,173	6	242	0	6
	2007	568	17,017	4,318	–	101	185	–	55,081	1,173	6	242	0	6
	2008	282	2,420	919	2	7	195	–	7,566	1,448	3	291	–	18
	2009	644	3,164	903	10	7	195	–	7,566	1,449	3	291	–	18
	2010	469	3,555	1,026	5	7	195	–	7,566	1,448	3	291	–	18
	2011	228	2,652	1,167	4	16	195	–	7,566	1,448	3	291	–	18
	2012	152	4,629	763	4	7	195	–	7,566	1,448	3	291	–	18
	2013	226	6,515	1,679	12	9,229	3	–	15,193	944	0	114	–	1
	2014	159	4,185	1,315	–	9,229	3	–	15,193	944	0	114	–	1
	2015	280	2,659	1,610	7	9,229	3	–	15,193	944	0	114	–	1
	2016	137	2,555	1,900	6	9,229	3	–	15,193	944	0	114	–	1
	2017	108	1,977	1,929	3	7,464	–	–	2,954	653	1	0	2	–
	2018	203	1,188	2,553	10	7,464	–	–	2,954	655	1	0	2	–
	2019	115	689	1,211	54	7,467	–	–	2,959	657	1	0	2	–
	2020	116	815	2,504	7	7,461	–	–	2,949	653	1	0	2	–

Original land use		Forest land				Cropland		Grassland			Wetlands			
Destination land use	Year	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 planted forest	Post-1989 natural forest	Annual	Perennial	High producing	Low producing	With woody biomass	Open water	Vegetated	Settlements	Other land
	2021	145	804	1,321	61	6,845	–	–	2,737	520	1	0	–	–
	2022	145	230	1,624	61	6,845	–	–	2,737	520	1	0	–	–
Grassland – low producing	1990	905	–	–	–	0	4	1	–	1,379	7	74	–	18
	1991	905	–	–	–	0	4	1	–	1,379	7	74	–	18
	1992	905	–	–	–	0	4	1	–	1,379	7	74	–	18
	1993	905	–	–	–	0	4	1	–	1,379	7	74	–	18
	1994	905	–	–	–	0	4	1	–	1,379	7	74	–	18
	1995	905	–	–	–	0	4	1	–	1,379	7	74	–	18
	1996	905	–	–	–	0	4	1	–	1,379	7	74	–	18
	1997	905	–	–	–	0	4	1	–	1,379	7	74	–	18
	1998	905	–	–	–	0	4	1	–	1,379	7	74	–	18
	1999	905	–	–	–	0	4	1	–	1,379	7	74	–	18
	2000	905	296	–	–	0	4	1	–	1,379	7	74	–	18
	2001	905	284	–	–	0	4	1	–	1,379	7	74	–	18
	2002	905	192	106	–	0	4	1	–	1,379	7	74	–	18
	2003	905	422	336	–	0	4	1	–	1,379	7	74	–	18
	2004	905	974	308	–	0	4	1	–	1,379	7	74	–	18
	2005	905	1,997	351	–	0	4	1	–	1,379	7	74	–	18
	2006	905	2,513	301	–	0	4	1	–	1,379	7	74	–	18
	2007	905	3,335	722	–	0	4	1	–	1,379	7	74	–	18
	2008	317	968	174	4	–	3	547	–	2,477	4	95	–	35
	2009	800	1,342	932	23	–	3	547	–	2,477	4	95	–	35
	2010	512	2,179	468	8	–	3	547	–	2,477	4	95	–	35
	2011	314	1,972	827	84	–	3	547	–	2,477	4	95	–	35
	2012	340	2,370	432	15	–	3	547	–	2,477	4	95	–	35
	2013	496	2,303	771	30	–	–	285	–	1,684	5	31	166	37

Original land use		Forest land				Cropland		Grassland			Wetlands			
Destination land use	Year	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 planted forest	Post-1989 natural forest	Annual	Perennial	High producing	Low producing	With woody biomass	Open water	Vegetated	Settlements	Other land
	2014	245	2,274	700	54	–	–	285	–	1,684	5	31	166	37
	2015	196	1,619	681	22	–	–	285	–	1,684	5	31	166	37
	2016	296	1,805	1,198	46	–	–	285	–	1,684	5	31	166	37
	2017	158	1,167	1,841	44	1	–	339	–	1,825	–	5	0	–
	2018	252	663	1,479	56	1	–	339	–	1,832	–	5	0	–
	2019	174	638	670	23	1	–	339	–	1,851	–	5	0	–
	2020	174	751	1,509	28	1	–	339	–	1,812	–	5	0	–
	2021	201	525	785	36	1	–	338	–	1,365	–	5	–	–
	2022	201	84	964	36	1	–	338	–	1,365	–	5	–	–
Grassland – with woody biomass	1990	317	–	–	–	3	7	738	3,716	–	13	1	0	71
	1991	317	–	–	–	3	7	738	3,716	–	13	1	0	71
	1992	317	–	–	–	3	7	738	3,716	–	13	1	0	71
	1993	317	–	–	–	3	7	738	3,716	–	13	1	0	71
	1994	317	–	–	–	3	7	738	3,716	–	13	1	0	71
	1995	317	–	–	–	3	7	738	3,716	–	13	1	0	71
	1996	317	–	–	–	3	7	738	3,716	–	13	1	0	71
	1997	317	–	–	–	3	7	738	3,716	–	13	1	0	71
	1998	317	–	–	–	3	7	738	3,716	–	13	1	0	71
	1999	317	–	–	–	3	7	738	3,716	–	13	1	0	71
	2000	317	165	–	–	3	7	738	3,716	–	13	1	0	71
	2001	317	158	–	–	3	7	738	3,716	–	13	1	0	71
	2002	317	107	55	–	3	7	738	3,716	–	13	1	0	71
	2003	317	235	173	–	3	7	738	3,716	–	13	1	0	71
	2004	317	542	159	–	3	7	738	3,716	–	13	1	0	71
	2005	317	1,112	181	–	3	7	738	3,716	–	13	1	0	71
	2006	317	1,399	155	–	3	7	738	3,716	–	13	1	0	71

Original land use		Forest land				Cropland		Grassland			Wetlands			
Destination land use	**Year**	**Pre-1990 natural forest**	**Pre-1990 planted forest**	**Post-1989 planted forest**	**Post-1989 natural forest**	**Annual**	**Perennial**	**High producing**	**Low producing**	**With woody biomass**	**Open water**	**Vegetated**	**Settlements**	**Other land**
	2007	317	1,856	371		3	7	738	3,716		13	1	0	71
	2008	239	319	59	8	3	1	571	1,853	–	–	1	–	21
	2009	983	990	165	22	3	1	571	1,860	–	–	1	–	21
	2010	862	678	188	14	3	1	571	1,853	–	–	1	–	21
	2011	475	596	148	1	3	1	571	1,853	–	–	1	–	21
	2012	618	545	451	41	3	1	571	1,853	–	–	1	–	21
	2013	415	737	288	74	–	–	95	479	–	–	0	–	9
	2014	216	445	1,292	109	–	–	95	479	–	–	0	–	9
	2015	463	699	371	94	–	–	95	479	–	–	0	–	9
	2016	344	611	461	102	–	–	95	479	–	–	0	–	9
	2017	203	689	836	50	1	–	57	155	–	1	1	1	1
	2018	72	263	659	65	1	–	57	155	–	1	1	1	1
	2019	260	362	704	31	1	–	57	155	–	1	1	1	1
	2020	197	398	561	79	1	–	57	155	–	1	1	1	1
	2021	177	323	437	20	1	–	25	108	–	1	1		1
	2022	177	52	537	20	1	–	25	108	–	1	1	–	1
Wetlands – open water	1990	5	–	–	–	2	0	49	144	9	–	21	1	35
	1991	5	–	–	–	2	0	49	144	9	–	21	1	35
	1992	5	–	–	–	2	0	49	144	9	–	21	1	35
	1993	5	–	–	–	2	0	49	144	9	–	21	1	35
	1994	5	–	–	–	2	0	49	144	9	–	21	1	35
	1995	5	–	–	–	2	0	49	144	9	–	21	1	35
	1996	5	–	–	–	2	0	49	144	9	–	21	1	35
	1997	5	–	–	–	2	0	49	144	9	–	21	1	35
	1998	5	–	–	–	2	0	49	144	9	–	21	1	35
	1999	5	–	–	–	2	0	49	144	9	–	21	1	35

Original land use		Forest land				Cropland		Grassland			Wetlands			
Destination land use	Year	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 planted forest	Post-1989 natural forest	Annual	Perennial	High producing	Low producing	With woody biomass	Open water	Vegetated	Settlements	Other land
	2000	5	2	–	–	2	0	49	144	9	–	21	1	35
	2001	5	2	–	–	2	0	49	144	9	–	21	1	35
	2002	5	1	1	–	2	0	49	144	9	–	21	1	35
	2003	5	3	3	–	2	0	49	144	9	–	21	1	35
	2004	5	7	3	–	2	0	49	144	9	–	21	1	35
	2005	5	14	3	–	2	0	49	144	9	–	21	1	35
	2006	5	18	3	–	2	0	49	144	9	–	21	1	35
	2007	5	24	6	–	2	0	49	144	9	–	21	1	35
	2008	–	8	14	–	69	3	302	25	10	–	21	1	45
	2009	5	3		–	69	3	294	25	10	–	21	1	45
	2010	–	4		–	69	3	296	25	10	–	21	1	45
	2011	0	3	3	–	69	3	297	25	10	–	21	1	45
	2012	–	–	7	–	69	3	294	25	10	–	21	1	45
	2013	–	45	5	–	22	2	179	79	8	–	20	–	32
	2014	–	35	–	–	22	2	164	79	8	–	20	–	32
	2015	1	1	0	–	22	2	181	79	8	–	20	–	32
	2016	2	9	–	–	23	2	177	79	8	–	20	–	32
	2017	2	1	–	–	23	0	96	29	23	–	31	1	117
	2018	–	–	–	–	23	5	121	31	23	–	31	1	127
	2019	1	–	–	–	23	0	112	29	27	–	31	1	119
	2020	9		2	–	23	0	131	29	23	–	31	1	115
	2021	–	–	–	–	23	0	80	29	18	–	29	–	100
	2022	–	–	–	–	23	0	80	29	18	–	29	–	100
Wetlands – vegetated	1990	0	–	–	–	–	0	2	8	2	1	–	–	0
	1991	0	–	–	–	–	0	2	8	2	1	–	–	0
	1992	0	–	–	–	–	0	2	8	2	1	–	–	0

Original land use		Forest land				Cropland		Grassland			Wetlands			
Destination land use	Year	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 planted forest	Post-1989 natural forest	Annual	Perennial	High producing	Low producing	With woody biomass	Open water	Vegetated	Settlements	Other land
	1993	0	–	–	–	–	0	2	8	2	1	–	–	0
	1994	0	–	–	–	–	0	2	8	2	1	–	–	0
	1995	0	–	–	–	–	0	2	8	2	1	–	–	0
	1996	0	–	–	–	–	0	2	8	2	1	–	–	0
	1997	0	–	–	–	–	0	2	8	2	1	–	–	0
	1998	0	–	–	–	–	0	2	8	2	1	–	–	0
	1999	0	–	–	–	–	0	2	8	2	1	–	–	0
	2000	0	1	–	–	–	0	2	8	2	1	–	–	0
	2001	0	1	–	–	–	0	2	8	2	1	–	–	0
	2002	0	1	0	–	–	0	2	8	2	1	–	–	0
	2003	0	2	2	–	–	0	2	8	2	1	–	–	0
	2004	0	4	1	–	–	0	2	8	2	1	–	–	0
	2005	0	9	2	–	–	0	2	8	2	1	–	–	0
	2006	0	11	1	–	–	0	2	8	2	1	–	–	0
	2007	0	15	3	–	–	0	2	8	2	1	–	–	0
	2008	–	–	–	–	–	–	11	5	–	2	–	–	3
	2009	5	16	–	–	–	–	11	5	–	2	–	–	3
	2010	–	7	11	–	–	–	11	5	–	2	–	–	3
	2011	–	13	–	–	–	–	11	5	–	2	–	–	3
	2012	3	–	–	–	–	–	11	5	–	2	–	–	3
	2013	–	2	–	–	1	–	6	2	20	–	–	–	–
	2014	–	6	8	–	1	–	6	2	20	–	–	–	–
	2015	–	13		–	1	–	6	2	20	–	–	–	–
	2016	–	15	3	–	1	–	6	2	20	–	–	–	–
	2017	–	0	6	–	7	–	9	2	5	0	–	–	–
	2018	–	2	0	–	7	–	9	2	5	0	–	–	–

Original land use		Forest land				Cropland		Grassland			Wetlands			
Destination land use	Year	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 planted forest	Post-1989 natural forest	Annual	Perennial	High producing	Low producing	With woody biomass	Open water	Vegetated	Settlements	Other land
	2019	–	1	2	–	7	–	9	2	5	0	–	–	–
	2020	–	4	–	–	7	–	9	2	5	0	–	–	–
	2021	–	–	–	–	5	–	3	2	5	0	–	–	–
	2022	–	–	–	–	5	–	3	2	5	0	–	–	–
Settlements	1990	22	–	–	–	30	48	868	106	41	0	2	–	11
	1991	22	–	–	–	30	48	868	106	41	0	2	–	11
	1992	22	–	–	–	30	48	868	106	41	0	2	–	11
	1993	22	–	–	–	30	48	868	106	41	0	2	–	11
	1994	22	–	–	–	30	48	868	106	41	0	2	–	11
	1995	22	–	–	–	30	48	868	106	41	0	2	–	11
	1996	22	–	–	–	30	48	868	106	41	0	2	–	11
	1997	22	–	–	–	30	48	868	106	41	0	2	–	11
	1998	22	–	–	–	30	48	868	106	41	0	2	–	11
	1999	22	–	–	–	30	48	868	106	41	0	2	–	11
	2000	22	20	–	–	30	48	868	106	41	0	2	–	11
	2001	22	19	–	–	30	48	868	106	41	0	2	–	11
	2002	22	13	9	–	30	48	868	106	41	0	2	–	11
	2003	22	28	27	–	30	48	868	106	41	0	2	–	11
	2004	22	64	25	–	30	48	868	106	41	0	2	–	11
	2005	22	131	28	–	30	48	868	106	41	0	2	–	11
	2006	22	165	24	–	30	48	868	106	41	0	2	–	11
	2007	22	220	58	–	30	48	868	106	41	0	2	–	11
	2008	11	5	1	–	50	26	553	60	19	0	0	–	18
	2009	13	18	7	–	50	26	553	60	19	0	0	–	18
	2010	14	16	8	–	50	26	553	60	19	0	0	–	18
	2011	0	39	7	–	50	26	553	60	19	0	0	–	18

Original land use		Forest land				Cropland		Grassland			Wetlands			
Destination land use	Year	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 planted forest	Post-1989 natural forest	Annual	Perennial	High producing	Low producing	With woody biomass	Open water	Vegetated	Settlements	Other land
	2012	7	26	7	0	50	26	553	60	19	0	0	–	18
	2013	8	7	7	–	78	51	1,042	80	40	2	1	–	13
	2014	2	21	4	–	78	51	1,042	80	40	2	1	–	13
	2015	19	17	3	2	78	51	1,044	80	40	2	1	–	13
	2016	22	26	15	8	78	51	1,042	80	40	2	1	–	13
	2017	5	9	–	2	77	29	634	24	30	0	0	–	5
	2018	4	2	5		77	29	706	24	30	0	0	–	5
	2019	6	6	3	0	79	29	644	24	30	0	0	–	5
	2020	14	13	8		75	29	634	24	30	0	0	–	5
	2021	8	7	3	0	70	23	602	23	21	0	0	–	4
	2022	8	1	4	0	70	23	602	23	21	0	0	–	4
Other land	1990	22	–	–	–	0	1	41	89	18	2	3	0	–
	1991	22	–	–	–	0	1	41	89	18	2	3	0	–
	1992	22	–	–	–	0	1	41	89	18	2	3	0	–
	1993	22	–	–	–	0	1	41	89	18	2	3	0	–
	1994	22	–	–	–	0	1	41	89	18	2	3	0	–
	1995	22	–	–	–	0	1	41	89	18	2	3	0	–
	1996	22	–	–	–	0	1	41	89	18	2	3	0	–
	1997	22	–	–	–	0	1	41	89	18	2	3	0	–
	1998	22	–	–	–	0	1	41	89	18	2	3	0	–
	1999	22	–	–	–	0	1	41	89	18	2	3	0	–
	2000	22	13	–	–	0	1	41	89	18	2	3	0	–
	2001	22	13	–	–	0	1	41	89	18	2	3	0	–
	2002	22	9	5	–	0	1	41	89	18	2	3	0	–
	2003	22	19	16	–	0	1	41	89	18	2	3	0	–
	2004	22	44	15	–	0	1	41	89	18	2	3	0	–

Original land use		Forest land				Cropland		Grassland			Wetlands			
Destination land use	Year	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 planted forest	Post-1989 natural forest	Annual	Perennial	High producing	Low producing	With woody biomass	Open water	Vegetated	Settlements	Other land
	2005	22	89	17	–	0	1	41	89	18	2	3	0	–
	2006	22	112	14	–	0	1	41	89	18	2	3	0	–
	2007	22	149	35	–	0	1	41	89	18	2	3	0	–
	2008	15	50	–	–	–	0	121	137	58	16	7	–	–
	2009	82	46	13	–	–	0	121	137	58	16	7	–	–
	2010	119	33	7	2	–	0	121	137	58	16	7	–	–
	2011	135	74	8	–	–	0	121	137	58	16	7	–	–
	2012	141	59	11	–	–	0	121	137	58	16	7	–	–
	2013	104	84	25	–	1	0	40	90	79	12	20	–	–
	2014	55	96	23	–	1	0	40	90	79	12	20	–	–
	2015	103	144	2	–	1	0	40	90	79	12	20	–	–
	2016	71	156	108	–	1	0	40	90	79	12	20	–	–
	2017	14	26	46	–	–	–	15	21	76	5	1	0	–
	2018	34	21	23	–	–	–	14	19	76	5	1	0	–
	2019	51	13	19	–	–	–	14	19	76	5	1	0	–
	2020	43	13	2	–	–	–	14	19	76	5	1	0	–
	2021	43	16	9	0	–	–	10	18	65	2	1	0	–
	2022	43	3	11	0	–	–	10	18	65	2	1	0	–

A5.2.4 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, 2006b) using the equation:

$$\Delta C = [(SOC_0 - SOC_{(0\text{-}T)})/20] \times A \qquad (A5.2.1)$$

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., 2014). 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 A5.2.1). 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 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. 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 $C_{i,j}^{0-30\mathrm{cm}}$ in land use category *i* and soil–climate class *j* as:

$$C_{i,j}^{0-30\mathrm{cm}} = M + L_i + S_j + b.SR + \varepsilon \qquad (A5.2.2)$$

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 A5.2.2 (McNeill et al., 2014).

Soil data sets

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

Historical soils: This data set is derived primarily from the National Soils Database,[7] 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).

[7] National Soils Database: https://viewer-nsdr.landcareresearch.co.nz/search.

Pre-1990 natural forest soils: This data set was gathered between 2002 and 2007 as part of the pre-1990 Natural Forest Survey, with soil subsampled on an 8-kilometre grid across the country (Garrett, unpublished; see section A5.2.5, '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 historical 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 research combining 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).

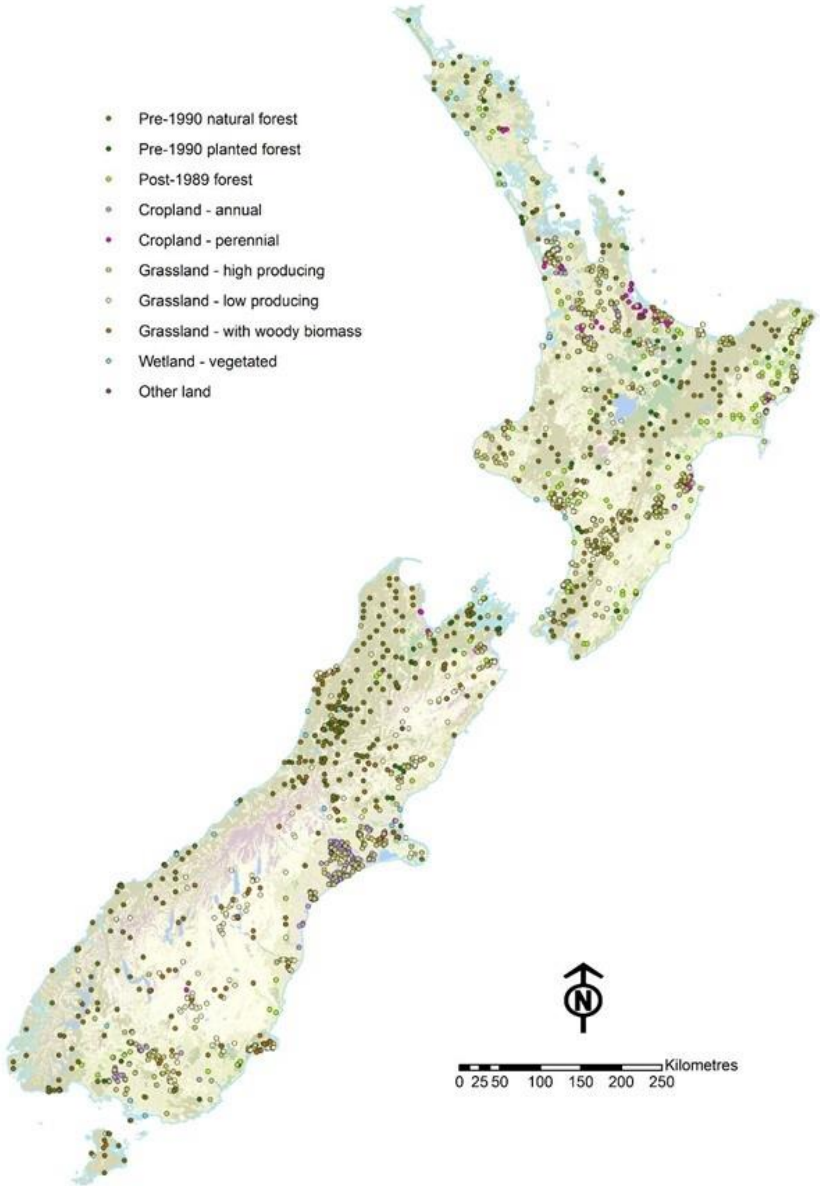
Post-1989 natural and planted forest data: This data set was added to the analysis in 2014. It contains data collected specifically for United Nations Framework Convention on Climate Change (Convention) reporting from 90 post-1989 forest sites across New Zealand (Basher et al., unpublished; Interpine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

Together, the five combined data sets cover most of New Zealand, including Stewart Island (figure A5.2.8). 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 among regions (figure A5.2.8). 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., 2014).

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 A5.2.8 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 producing grassland. 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: This contemporary digital soil spatial information system for New Zealand (Lilburne et al., 2012) 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 of 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[8] 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 (table A5.2.7). Steady state SOC stocks for each land use (table A5.2.8) 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 A5.2.7). These values are used in equation A5.2.1 (as SOC_0 and $SOC_{(0-T)}$) to calculate soil carbon changes due to land-use change.

Table A5.2.7 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.

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

Table A5.2.8 **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 provides 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), unpublished(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:

$$\sigma_{i,j} = \sqrt{Var\ (L_i) + Var\ (L_j) - 2.Cov\ (L_i, L_j)} \qquad (A5.2.3)$$

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., 2014).

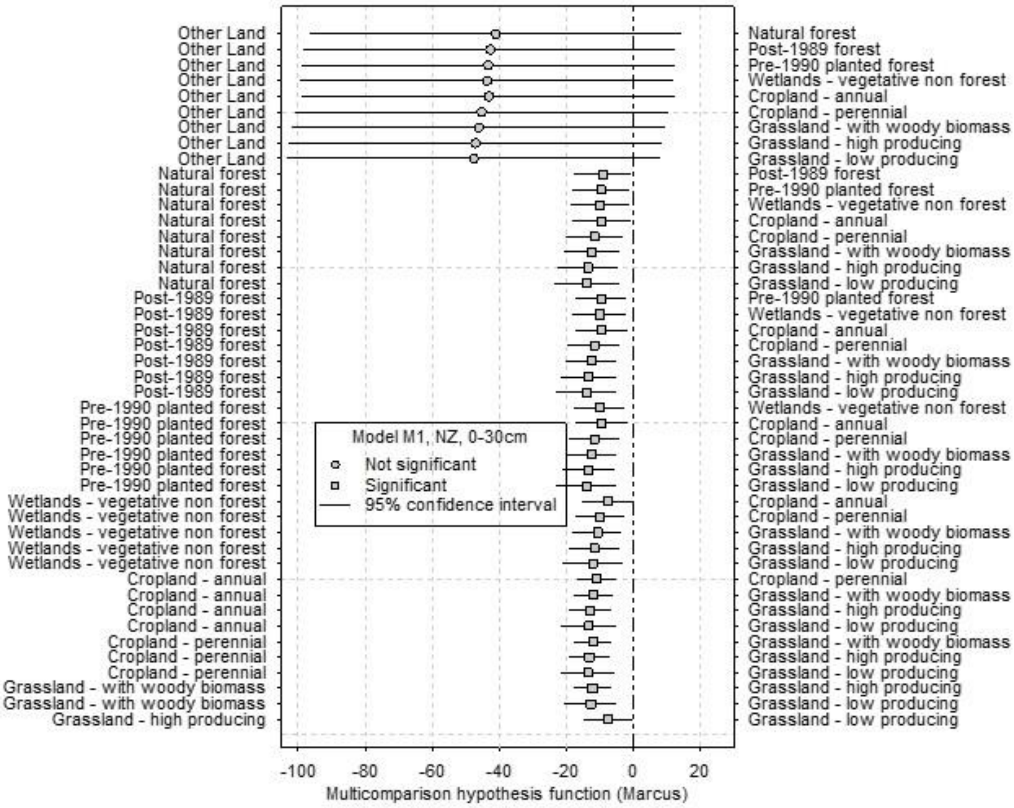
Although equation A5.2.3 provides a mathematically straightforward way to estimate the significance of a single transition from one land use category to another (a comparison-wise significance), it is often desirable to be able to determine whether a number of land use categories are likely to be significantly 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 et al., 2014).

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 et al., 2014), 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* (figure A5.2.9).

Figure A5.2.9 Result of applying the Marcus multi-comparison test to the adopted model



Source: McNeill et al. (2014)

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 (figure A5.2.9), 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 0.6 per cent of all land-use change detected between 1990 and 2022.

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 (table A5.2.8) 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, 2006b) 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 main land-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 of which are 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 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, 2006b) to estimate organic soil emissions (table A5.2.9). 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 degrees Celsius 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 A5.2.9 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, 2006b, section 4.2.3.2).
Pre-1990 and post-1989 planted and natural forest	Temperate	0.68 (range 0.41–1.91)	IPCC (2006b, section 4.2.3.2, table 4.6)
Cropland	Cold temperate Warm temperate	5.0 ± 90% 10.0 ± 90%	IPCC (2006b, section 5.2.3.2, table 5.6)
Grassland	Cold temperate Warm temperate	0.25 ± 90% 2.5 ± 90%	IPCC (2006b, 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, 2006b, chapter 7.
Settlements	Cold temperate Warm temperate	5.0 ± 90% 10.0 ± 90%	Cropland emission factors used (IPCC, 2006b, section 8.2.3.2)
Other land	NA	NE	No IPCC guidance is available (IPCC, 2006b, 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 (2006b, 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.

A5.2.5 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 deforestation and harvesting areas for pre-1990 and post-1989 planted forests using the following steps.

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, 2023a) and adjusted to calendar years, plus the mapped deforestation area of post-1989 forest. The mapped deforestation of post-1989 planted forest is added because the NEFD is thought to underestimate destocking of forests belonging to small forest growers (Ministry for Primary Industries, 2023a), which comprise a higher proportion of the post-1989 planted forest estate.
2. Total destocking area between 2013 and 2022 is calculated by combining:
   a) planted forest yield tables
   b) the destocking age profile (under 'Calculation of harvest area by age and forest age profile' below)
   c) estimated roundwood volume removed from planted forests (Ministry for Primary Industries, 2023b).

   This approach estimates the total destocking area required to achieve the 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 products* category from 2013 to 2022 (figure A5.2.13).
3. The change in approach from 2013 onwards is due to concerns about 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, 2023b).

Deforestation area

1. Deforestation area from 1990 to 2020, for all forest types, is estimated from mapping data and supplementary statistics.
2. Deforestation area for 2021 and 2022, for pre-1990 and post-1989 planted forest, is extrapolated from the total deforestation in mapped years and the trend present in the pre-1990 planted forest deforestation results of the Afforestation and Deforestation Intentions Survey (Manley, 2023) (see section A5.2.2).

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 2020 is based on mapped harvest area data.
3. From 2021 onwards, a harvest fraction approach is used to estimate the total destocking area in post-1989 and pre-1990 planted forest combined. This approach applies the overall harvest age profile to the forest age profile in both forest types, to partition the area available to be harvested in each type. This provides an estimate of the harvest area to occur at each age in both forest types, as a proportion of the total destocking area.
4. Post-1989 harvest area from 2021 is calculated as post-1989 total destocking area minus post-1989 deforestation area. A gross stocked to net stocked area adjustment is then applied. This reduces the estimated post-1989 harvest area but does not impact the total destocking estimate.
5. The harvest area of pre-1990 planted forest is then calculated for 1990 to 2022 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 (destocking age profile). This is because destocking at a single age (28 years) is not considered to reflect the actual destocking that occurs and can lead to the destocking 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 (see section A5.2.5, ‘Planted forest yield tables’ and tables A5.2.19 to A5.2.21) 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. The destocking age profile is derived from the loss of forest area in each age class reported in the annual updates to the NEFD forest age profile (Ministry for Primary Industries, 2023a). With each update, the losses in forest area for all age classes are combined to create an average destocking age profile, as a percentage of total destocking area. The average 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. Table A5.2.10 demonstrates the destocking age profile for all planted forest expressed as a percentage for the ages 15–45 years. Note that there is a small proportion of destocking that occurs before the age of 15 years (not shown in table A5.2.10). This predominately relates to post-1989 destocking that occurs prior to 2008.

An average harvest age of 28 years is assumed for 1990 to 1995. For subsequent years, the average harvest age is sourced from annual NEFD publications (Ministry for Primary Industries, 2023a). 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. The average harvesting age is considered to represent the entire planted forest estate (i.e., both pre-1990 and post-1989 forests).

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 area by age profile in 2022 is demonstrated in figure A5.2.10 for pre-1990 planted forest and in figure A5.2.11 for post-1989 planted forest. For pre-1990 forest, the rate of harvesting that occurs between 1980 and 1989 is now constrained. This results in no harvesting occurring in specific age classes, which presents as a bi-modal distribution in the harvest age profile. This is a change from the pre-1990 forest harvest area profile presented in previous submissions, which followed a normal distribution, similar to that seen in the current submission for post-1989 planted forest.

Both pre-1990 and post-1989 planted forests share the same underlying destocking and harvest age profiles. Therefore, as the rate of harvest increases in the post-1989 estate (with increasing harvest of younger trees due to the forest age profile of post-1989 forests), the proportion of harvesting of pre-1990 forest in these ages is reduced and the average harvest age of pre-1990 planted forest increases. This ensures that the average harvest age and harvest age profile are representative of the entire planted forest estate.

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 A5.2.2), 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 about 19,000 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 that for an estimated area of about 3,000 hectares of forest to be harvested at age 30 in 2010, that same area would need 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 A5.2.2), or assigned harvest and replanting events. The harvest and replanting events that occur between 1980 and 1989 are constrained based on historical roundwood removal volume data, converted to area (Ministry for Primary Industries, 2023b).

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 the older stands of forest in figure A5.2.14. The forest area by age in the most recent reporting year is then assigned a corresponding plant date.

The approach to calculating the pre-1990 planted forest new planting time series has been improved for the 2024 submission.

Table A5.2.10 Proportion of total destocking area by age across all planted forest, 1990–2022

	Destocking age by year (%)																														
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
2022	0.8	1.2	1.0	1.1	1.4	1.3	1.2	1.2	1.8	2.5	6.9	11.8	14.2	13.9	12.1	9.8	0.5	0.3	0.0	0.0	0.0	2.6	2.1	3.7	3.7	2.4	1.8	0.0	0.2	0.2	0.2
2021	0.9	1.5	0.9	1.1	1.4	1.3	1.2	1.2	1.8	2.5	6.8	11.7	14.1	13.9	12.0	0.7	0.4	0.0	0.0	2.5	3.8	3.4	5.3	5.0	3.3	2.5	0.1	0.2	0.2	0.2	0.2
2020	2.7	1.2	1.0	0.8	1.4	1.1	1.4	0.7	2.0	1.5	4.5	10.0	12.7	13.5	1.6	1.2	5.6	3.1	4.6	5.1	4.2	6.3	5.9	3.7	2.8	0.1	0.4	0.2	0.2	0.2	0.2
2019	0.1	1.2	1.0	0.8	1.4	1.0	1.4	0.5	2.0	1.3	4.1	9.7	12.5	7.5	1.1	10.6	8.1	7.8	7.5	5.7	2.6	2.3	4.6	3.2	0.1	0.5	0.5	0.2	0.2	0.2	0.2
2018	0.4	1.3	1.0	1.1	1.4	1.3	1.3	1.0	2.0	2.1	6.0	11.3	12.8	7.7	11.4	9.6	7.5	5.9	4.2	2.9	2.2	1.9	1.4	0.0	0.6	0.5	0.4	0.2	0.2	0.2	0.2
2017	0.0	1.9	1.3	1.0	2.2	1.3	2.2	0.4	3.3	1.5	6.0	9.6	12.3	12.8	10.8	8.6	6.6	5.4	3.8	2.5	1.8	1.7	0.1	0.5	0.5	0.5	0.5	0.2	0.2	0.2	0.1
2016	0.4	1.4	1.1	1.1	1.6	1.4	1.5	1.1	2.2	2.2	4.7	9.3	11.5	11.9	11.1	9.4	7.6	6.2	3.8	2.6	2.0	1.7	1.2	0.7	0.6	0.5	0.4	0.2	0.2	0.2	0.2
2015	0.3	1.2	1.0	1.0	1.8	1.2	1.5	1.0	1.8	1.6	4.3	9.3	11.0	12.1	11.3	9.8	7.6	5.9	4.3	3.0	2.4	1.7	1.4	0.9	0.7	0.5	0.4	0.2	0.2	0.2	0.2
2014	0.7	1.0	1.0	1.1	1.3	1.3	0.8	1.4	1.4	2.5	7.1	10.3	11.5	12.2	10.8	8.6	6.9	5.4	3.7	2.9	1.8	1.7	1.2	0.9	0.6	0.5	0.3	0.3	0.2	0.2	0.2
2013	0.9	1.4	1.2	1.2	1.3	1.3	1.0	1.6	1.3	2.7	6.5	8.8	11.9	12.3	10.6	8.7	7.0	5.3	4.5	2.1	2.1	1.8	1.4	0.7	0.6	0.4	0.4	0.3	0.2	0.2	0.2
2012	0.8	1.0	0.9	1.2	1.2	1.3	0.8	1.4	1.5	2.8	6.6	11.2	11.5	11.4	11.5	7.9	7.1	6.0	3.6	2.3	2.1	2.0	1.0	0.7	0.5	0.5	0.4	0.3	0.2	0.2	0.2
2011	1.5	1.1	0.9	1.0	1.3	1.2	1.0	1.2	1.6	2.2	5.8	10.1	12.3	12.4	10.7	8.5	7.4	5.5	3.8	2.4	2.3	1.8	1.2	0.7	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	1.2	1.0	1.3	1.4	2.5	6.5	10.3	12.6	12.2	10.6	8.7	7.1	5.3	3.7	2.6	2.1	1.7	1.0	0.8	0.6	0.5	0.4	0.3	0.2	0.2	0.2
2009	0.9	1.0	0.9	1.2	1.1	1.4	0.7	1.6	1.3	3.0	7.7	11.2	12.9	11.8	10.3	8.2	6.6	4.9	3.4	2.4	2.0	1.7	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.2
2008	1.0	1.0	0.8	1.3	1.1	1.4	0.6	1.8	1.2	3.2	8.3	11.5	13.0	11.7	10.1	7.9	6.4	4.7	3.2	2.3	2.0	1.5	1.0	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.3
2007	2.9	3.3	2.8	1.2	0.9	1.3	0.5	1.6	1.1	3.0	7.6	10.4	11.7	10.4	12.9	7.1	3.8	6.2	2.9	1.3	1.7	1.6	1.1	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.2
2006	1.8	2.0	0.7	1.3	1.0	1.3	0.5	1.7	1.2	3.2	8.0	11.0	12.4	11.0	12.6	7.5	6.1	4.4	3.1	1.4	2.0	1.7	1.1	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.2
2005	2.4	0.9	0.8	1.2	1.0	1.3	0.7	1.7	1.4	3.9	8.6	11.4	12.4	10.9	12.0	7.3	5.9	4.3	2.1	2.4	1.9	1.6	1.0	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.2
2004	1.0	0.9	1.0	1.2	1.2	1.0	1.1	1.6	2.1	5.6	9.8	12.2	12.3	10.7	10.2	7.1	5.6	3.4	2.9	2.2	1.8	1.4	0.8	0.7	0.5	0.4	0.3	0.2	0.2	0.2	0.3
2003	1.0	0.8	1.1	1.1	1.3	0.9	1.3	1.5	2.5	6.5	10.4	12.5	12.2	10.6	9.2	6.9	5.1	3.8	2.7	2.1	1.8	1.2	0.8	0.6	0.5	0.4	0.2	0.2	0.2	0.2	0.3
2002	1.0	0.8	1.2	1.1	1.4	0.7	1.6	1.3	3.0	7.6	11.1	12.9	11.9	10.3	8.5	6.6	5.0	3.5	2.5	2.1	1.7	1.0	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.3	0.3
2001	1.0	0.8	1.3	1.0	1.4	0.6	1.8	1.2	3.3	8.5	11.6	13.1	11.7	10.0	8.1	6.5	4.7	3.3	2.3	2.0	1.7	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.3	0.3
2000	1.0	0.7	1.4	1.0	1.5	0.5	2.0	1.2	3.6	9.0	11.9	13.2	11.5	9.4	8.3	6.4	4.7	3.0	2.2	2.1	1.6	0.8	0.7	0.5	0.5	0.3	0.2	0.2	0.2	0.3	0.3
1999	1.0	0.8	1.1	1.1	1.3	0.9	1.4	1.4	2.6	6.7	10.6	12.6	12.1	10.5	8.8	6.9	5.3	3.7	2.6	2.1	1.8	1.1	0.8	0.6	0.5	0.4	0.2	0.2	0.2	0.2	0.3
1998	1.1	0.9	0.9	1.2	1.1	1.2	0.9	1.7	1.9	5.0	9.5	12.1	12.6	11.0	9.6	7.4	5.8	4.2	2.9	2.2	1.9	1.4	0.8	0.6	0.5	0.4	0.3	0.2	0.2	0.2	0.3
1997	1.1	0.9	0.9	1.3	1.1	1.2	0.8	1.7	1.7	4.4	9.2	11.9	12.8	11.2	9.7	7.5	6.0	4.3	3.0	2.2	1.9	1.5	0.8	0.7	0.5	0.5	0.3	0.2	0.2	0.2	0.3

	Destocking age by year (%)																														
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
1996	1.1	0.9	0.8	1.3	1.1	1.3	0.8	1.7	1.6	4.3	9.1	11.9	12.8	11.3	9.8	7.6	6.1	4.4	3.0	2.2	1.9	1.5	0.8	0.7	0.5	0.5	0.3	0.2	0.2	0.2	0.3
1995	1.1	0.9	0.8	1.3	1.1	1.3	0.7	1.8	1.5	4.1	9.0	11.8	12.8	11.0	10.1	7.6	6.1	4.4	3.0	2.2	1.9	1.5	0.8	0.7	0.5	0.5	0.3	0.2	0.2	0.2	0.3
1994	1.1	1.0	0.8	1.3	1.0	1.4	0.6	1.8	1.3	3.6	8.7	11.7	13.0	11.4	10.1	7.7	6.3	4.6	3.1	2.2	2.0	1.6	0.9	0.7	0.5	0.5	0.3	0.2	0.2	0.2	0.3
1993	1.1	1.0	0.8	1.3	1.0	1.4	0.6	1.8	1.3	3.6	8.7	11.7	13.0	11.0	10.6	7.7	6.3	4.6	3.1	2.2	2.0	1.6	0.9	0.7	0.5	0.5	0.3	0.2	0.2	0.2	0.3
1992	1.1	1.0	0.8	1.3	1.0	1.4	0.6	1.8	1.3	3.6	8.7	11.7	13.0	11.1	10.5	7.7	6.3	4.6	3.1	2.2	2.0	1.6	0.9	0.7	0.5	0.5	0.3	0.2	0.2	0.2	0.3
1991	1.1	1.0	0.8	1.3	1.0	1.4	0.6	1.8	1.3	3.6	8.7	11.7	13.0	8.8	12.8	7.7	6.3	4.6	3.1	2.2	2.0	1.6	0.9	0.7	0.5	0.5	0.3	0.2	0.2	0.2	0.3
1990	1.1	1.0	0.8	1.3	1.0	1.4	0.6	1.8	1.3	3.6	8.7	11.7	13.0	8.8	12.9	7.7	6.3	4.6	3.1	2.2	2.0	1.6	0.9	0.7	0.5	0.5	0.3	0.2	0.2	0.2	0.3

Figure A5.2.10 Harvest area by age for pre-1990 planted forest in 2022

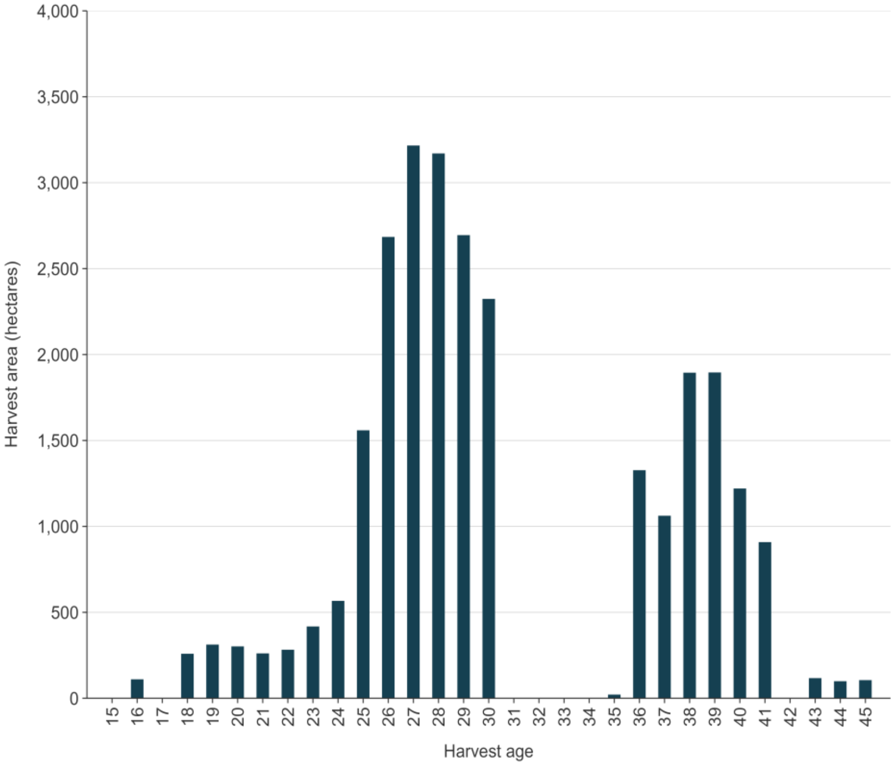
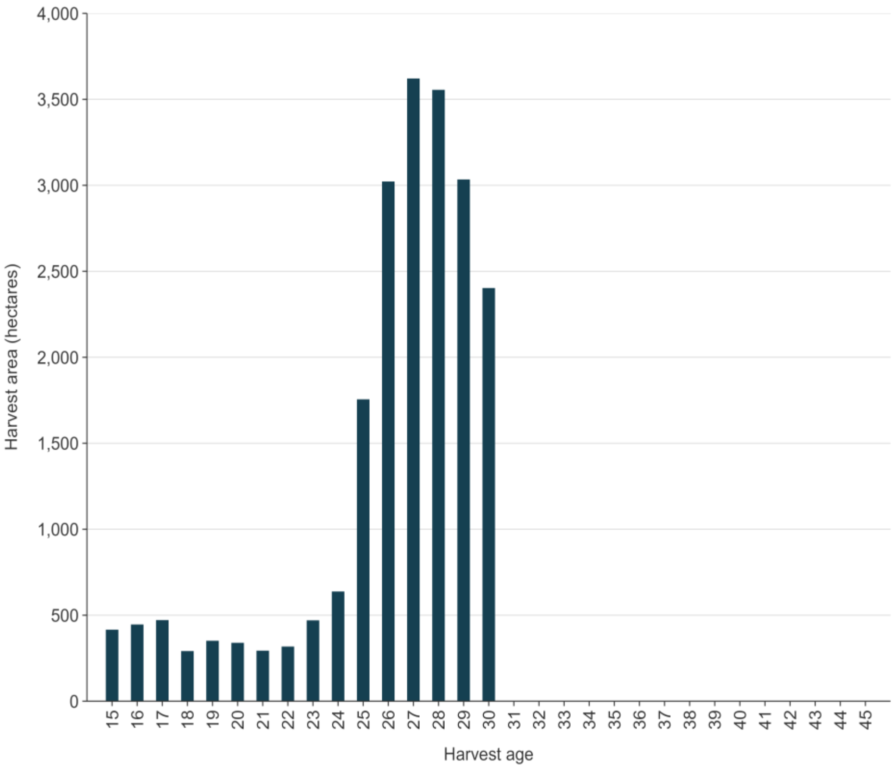


Figure A5.2.11 Harvest area by age for post-1989 planted forest in 2022



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 radius) 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 0.04-hectare plot (20 × 20 square metres) sits nested at the centre of each circular plot where all live stems with diameter at breast height (1.35 metres) greater than or equal to 2.5 centimetres are measured. Stems greater than 60 centimetres diameter at breast height are sampled on the 0.13-hectare 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 third round began in 2014 and is scheduled for completion in 2024. Fieldwork generally takes place between October and March each year. For the 2020/21 field season, data collection on the natural forest plot network was transitioned to an electronic data capture system, which is still in use. It had previously relied on a paper-based system. The electronic system has allowed for improved data quality and reduced 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 A5.2.11 summarises the method used to calculate the carbon stock in each biomass pool from the information collected at each plot.

Table A5.2.11 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:

   a) diameter, height and wood density (for trees)

   b) a non-specific conversion factor with diameter and height (for tree ferns)

   c) 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. For trees, the following carbon fractions are used to convert biomass volume to carbon: 0.51 for gymnosperms and 0.48 for broadleaf species (IPCC, 2006b)

2. **Below-ground biomass.** The below-ground biomass for each individual tree is calculated 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 summarised in table A5.2.12.

Table A5.2.12 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 it can 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 for wood that is in an advanced state of decay) and is underestimated by the monitoring programme (Kimberley et al., 2019). To correct for this, an adjustment factor derived by an approach developed by Kimberley et al. (2019) is applied (Paul et al., 2021). Dead wood is measured on all new plots and modelled for

re-measured plots using initial measurements, mortality recorded at re-measurement, 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. Ingrowth occurs when stems reach the minimum diameter measurement threshold (2.5 centimetres at breast height for the embedded 0.04-hectare square plot, and 60 centimetres at breast height for the 0.13-hectare circular plot) between two measurements (t_1 and t_2). To account for ingrowth and missing measurements, the diameters of trees measured at t_2 that were not measured at t_1 are predicted and used in the calculation of stock change, provided that the diameter at t_2 was above the threshold for field measurement. 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 diameters of trees measured at t_2 that were not measured at t_1 are 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 was included in Holdaway et al. (2017). This total 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 had 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) represent an improvement in stock and stock change estimates.

Third, the stem-level carbon stock change methods used by Paul et al. (2021) and 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 Paul et al. (2021).

Additional changes were made for the 2022 submission to align the plot-based carbon stock analysis with the mapped areas of each land cover sub-class. Pre-1990 tall and regenerating forest plots were previously classified using species composition (Wiser, 2016) to estimate the annual carbon stock change of each forest type. However, the tall and regenerating forest areas were estimated from mapped land cover (LCDBv3). This created a mismatch where carbon stock change estimates were not consistent with the forest area they were intended to represent. This was corrected for the 2022 submission by using the land cover approach (LCDBv5) to classify both the plots and the mapped areas of tall and regenerating forest.

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, following the measurement protocols established for the pre-1990 natural forest plots. In addition, pre-1989 plots include four circular sub-plots 1.5 metres in radius (7.06 square metres) nested within the 20 × 20 metre square plot designed to capture the smaller stems that can dominate younger regenerating forest. Twenty plots in post-1989 natural forests were established and measured for the first time in 2012. A second round of measurements, on 25 plots (of which 13 were also measured in 2012), was conducted in 2019. A yield table was generated from the plot measurements to provide estimates of carbon stock change (Paul et al., unpublished(a)). 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(a)).

Carbon stock change in the living biomass pool is calculated using the methods described in Paul et al. (unpublished (a)). In addition, a post-1989 natural forest yield table is included and is used in conversions from *Grassland with woody biomass* (table A5.2.18). 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 was 38.55 ± 10.23 tonnes C ha^{-1} (at the 95 per cent confidence interval) as of 31 December 2019 (Paul et al., unpublished(a)). 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(a)). 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(a)).

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 and Wakelin, unpublished; Paul et al., unpublished(b)) 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 *Pseudotsuga menziesii* (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 A5.2.12.

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 A5.2.13.

Table A5.2.13 Influence of individual site and management factors on predicted wood density for New Zealand planted forest

Factor affecting wood density	Range in predicted density (kg m^{-3})	Range in predicted density (% 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

Source: Beets et al., 2007

Note: C:N = carbon:nitrogen.

The stand tending model: New Zealand's plantation forests are intensively managed; 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)).

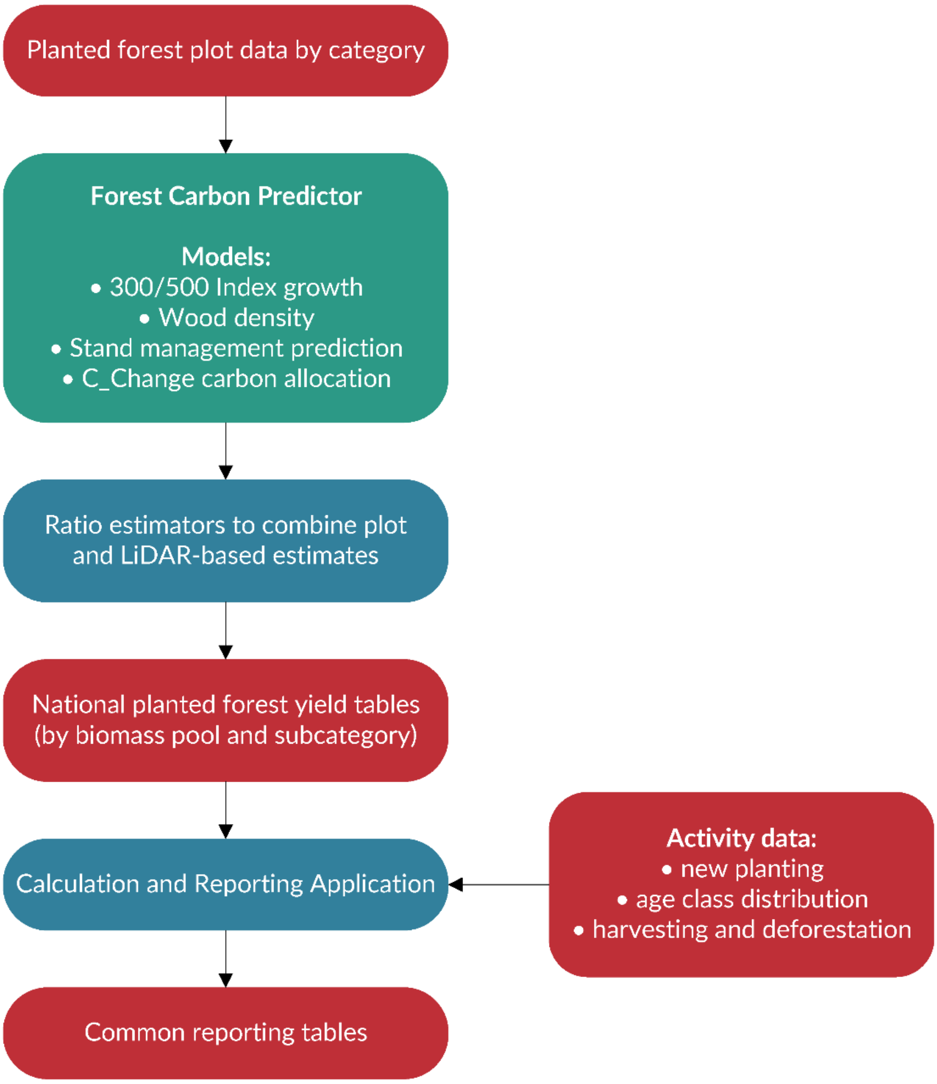
Below-ground biomass is derived from the above-ground biomass estimates. For plantation crop trees, below-ground biomass is assumed to be 15 per cent to 20 per cent of total production, depending on stand age (Beets et al., 1999). The ratio for non-crop trees and shrubs is 25 per cent (Coomes et al., 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, using plot area-weighted averages (figure A5.2.12). 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 measurements 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 A5.2.5, ‘Planted forest yield tables’.

Figure A5.2.12 New Zealand's planted forest inventory modelling process



Note: 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).

This submission uses updated post-1989 and pre-1990 planted forest yield tables. A single yield table is applied for post-1989 forests and two period-specific yield tables are applied to pre-1990 forests based on their plant date: pre-1990 forest planted before 1990 and pre-1990 forest planted from 1990 onwards. The revised yield tables are based on: the full first annual inventory cycle from 2016 to 2020, prior periodic inventories since 2007, and the newest measurements in 2021 and 2022 (the first two years in the second inventory cycle, which covers 2021 to 2025). Pre-1990 planted forests yield tables are area-weighted, whereas the post-1989 planted forest yield tables are area-weighted and age-adjusted. Age-adjusted tables include the effects of the age-class distribution of the inventory (Paul et al., unpublished(e)).

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(b)).

A stratification approach has been developed to stratify the data, allowing the modelling of period-dependent yield tables, creating historical 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(b)).

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 per site 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 second 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 2007 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 overall 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 these 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 was 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 in the field 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 and 2019, 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 the natural forest data collection manual (Ministry for the Environment, unpublished). Audit results are described in Beets and Holt (unpublished) and Paul and Dowling (unpublished). Similarly to pre-1990 natural forest, entry of data into the electronic database from paper-based plot sheets was subject to quality assurance by the Ministry for the Environment. Line-by-line checks were 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(a)).

Pre-1990 planted forest and post-1989 planted forest

Of the planted forest inventory plots, 7.5 per cent are randomly audited every year without the prior knowledge of the field 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 are required 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 planted forest 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

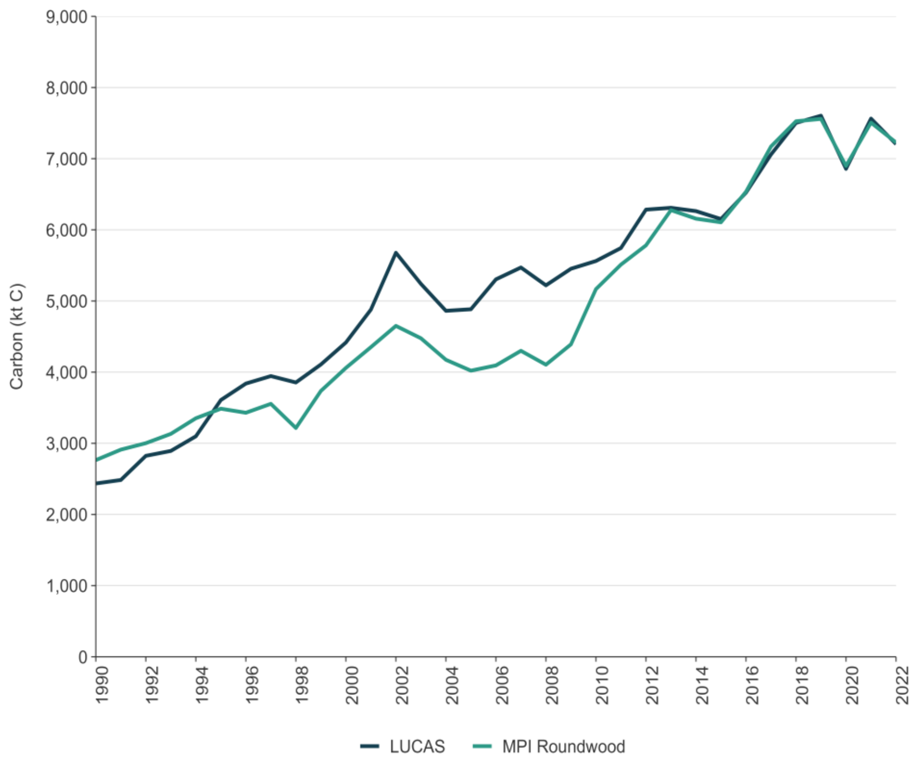
The above-ground biomass estimated to be removed from all planted forest destocking (all harvest and deforestation) by the LUCAS Calculation and Reporting Application (CRA) simulation, was compared with the estimated carbon stored in the annual Ministry for Primary Industries roundwood removal statistics (Ministry for Primary Industries, 2023b) (figure A5.2.13). The Ministry for Primary Industries' roundwood volume was converted to tonnes of carbon based on the carbon fractions used in the *Harvested wood products* (HWP) 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 for the period from 2013 to 2022. This is because roundwood volume is used to estimate the total destocking area over this period in the LUCAS CRA simulation. However, the two data sources deviate from 1990 to

2015. The LUCAS above-ground biomass losses from harvest are slightly lower than those estimated from roundwood volume statistics from 1990 to 1994, and greater from 1995 to 2015. The LUCAS above-ground biomass estimate may differ from the Ministry for Primary Industries roundwood removal estimate (Ministry for Primary Industries, 2023b) because the latter uses conversion factors for each forestry product to estimate the corresponding roundwood input required to produce the total forest product output. In addition, the Ministry for Primary Industries reports roundwood removal under-bark while the LUCAS estimate is over-bark.

Further assessments are planned to assess whether the consistency of forest carbon losses due to harvest versus carbon inputs into the *Harvested wood products* pool within the LUCAS model can be improved. For this, adjustments might need to be made to some of the input parameters to the planted forest model.

Figure A5.2.13 Comparison of the LUCAS estimate for above-ground biomass removed on planted forest destocking and carbon stored in roundwood production from 1990 to 2022



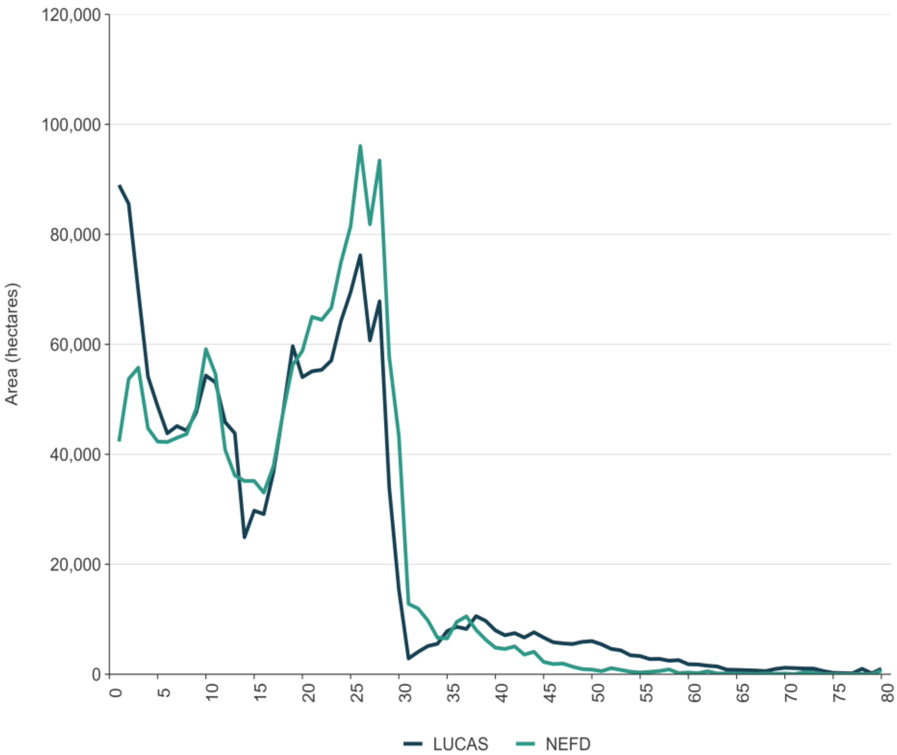
Note: MPI Roundwood = roundwood production data sourced from Ministry for Primary Industries (2023b). LUCAS = Land Use and Carbon Analysis System.

Planted forest age profile

The LUCAS net stocked area planted forest age profile at the end of the simulation in 2022 was compared with the NEFD planted forest age profile (Ministry for Primary Industries, 2023a) (figure A5.2.14). 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 2022 is based on a modelled simulation of forest activity. The LUCAS forest age profile used in the simulation is also influenced by mapped areas of post-1989 and pre-1990 forest and harvest activity, which are derived from a variety of sources (see section A5.2.5, ‘Calculation of harvest area’). The three areas of discrepancy between these two data sources are outlined below.

1. The total mapped area of post-1989 forest is smaller than the area of new planting from 1990 onwards that is reported in the NEFD. As a result, the forest area by age for this type of forest is scaled down relative to the NEFD estimate. This also explains why the LUCAS area is lower from ages 18 to 32.
2. The LUCAS pre-1990 planted forest age profile from ages 0 to 32 is driven by the reported harvested and replanted areas in the CRA simulation model, but with a one-year lag on replanting after harvest. The LUCAS estimates of harvest and replanting are therefore not consistent with the NEFD replanting estimates, resulting in a difference in the forest age profiles.
3. The LUCAS forest age profile from age 33 onwards represents forests planted before 1990. The LUCAS age profile of these forests follows the same pattern as the NEFD data (which they are based on) but reports 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 A5.2.14 Comparison between the planted forest age profile estimated from the LUCAS simulation of net stocked area for all planted forest (post-1989 and pre-1990) and the NEFD age profile for 2022



Note: The age profile starts at age 1 and does not include areas of forest that were planted or harvested and awaiting replanting in 2022. LUCAS = Land Use and Carbon Analysis System CRA Simulation; NEFD = National Exotic Forest Description.

LUCAS planted forest inventory plot measurements versus yield table values

The ability of the Forest Carbon Predictor to generate accurate yield tables was first validated in Beets et al. (2011b). The results indicated a good match between carbon stock and stock change predicted from the Forest Carbon Predictor with plot measurements.

An additional validation of the yield tables was undertaken in the 2022 NIR submission, as suggested by the expert review team during the review of the 2021 NIR submission. This validation compared yield table carbon stocks with the measured plot values from the 2016 to 2020 forest inventory. 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. This comparison has been updated in 2023 using data from the 2018 to 2022 forest inventory (table A5.2.14 and figures A5.2.15 to A5.2.17).

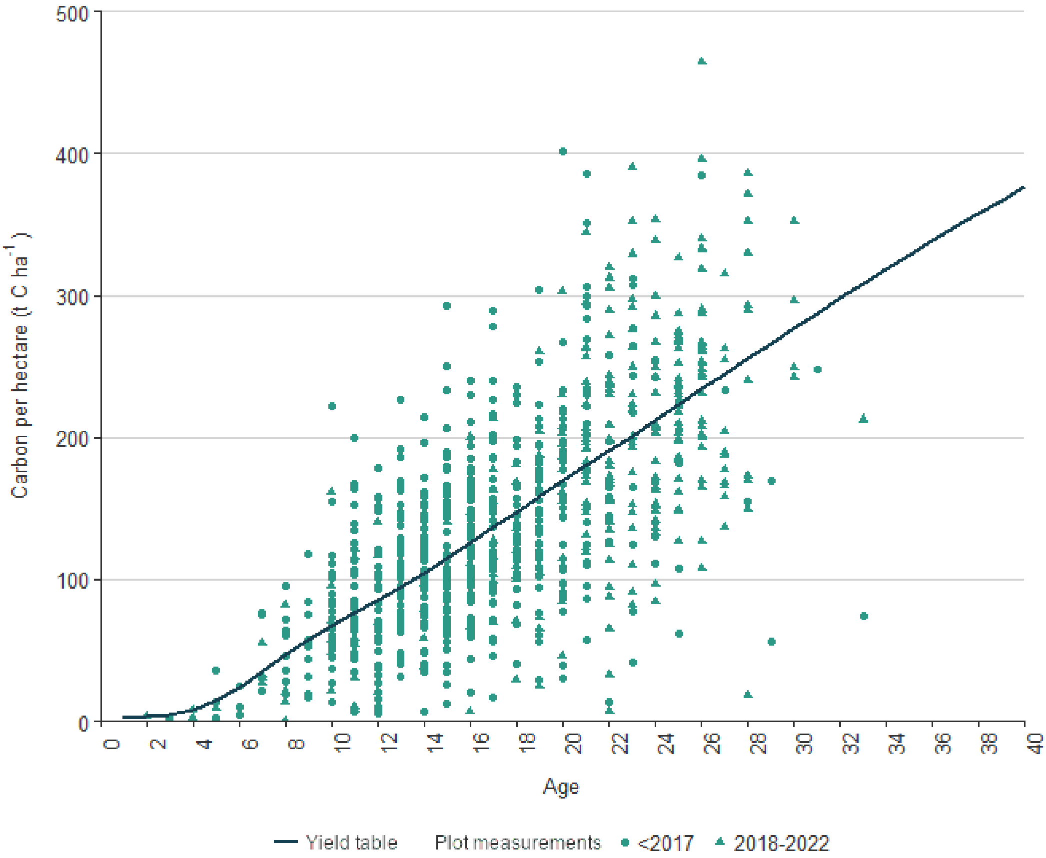
An area-weighted average carbon stock per hectare for each forest type was calculated from plots measured in the 2018 to 2022 planted forest inventory and from adjusted yield table values fitted to the ages of these plots (table A5.2.14). Note that because the Forest Carbon Predictor generates yield tables by utilising all data collected by the forest inventory (including previous measures of plots in the 2018 to 2022 inventory, as well as any plots that have since been harvested), this comparison is a rudimentary assessment of yield table fit to measured plot carbon stocks. 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 A5.2.14 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 2018–22 forest inventory			Yield table fitted to plot age		
Forest type	t C ha^{-1}	95% CI	Number of plots	t C ha^{-1}	95% CI	Difference t C ha^{-1}
Post-1989	180.3	10.8	270	183.3	7.5	-3.0
Pre-1990 – after 1990	102.4	10.5	233	113.8	5.6	-11.4
Pre-1990 – before 1990	233.6	47.8	18	309.5	24.0	-76.0

The average carbon stock per hectare plots measured between 2018 and 2022 in post-1989 planted forest was 180.3 ± 10.8 tonnes C ha^{-1}. When fitting the adjusted yield table carbon values to the measured plot ages, the average carbon stock per hectare is 183.5 ± 7.5 tonnes C ha^{-1} (table A5.2.14). On average, for post-1989 forests, the yield table estimates carbon stock per hectare to be 3.0 tonnes C ha^{-1} higher than the measured plot values. This suggests a relatively good fit and is within the average confidence interval (7.5 tonnes C ha^{-1}) of the yield table.

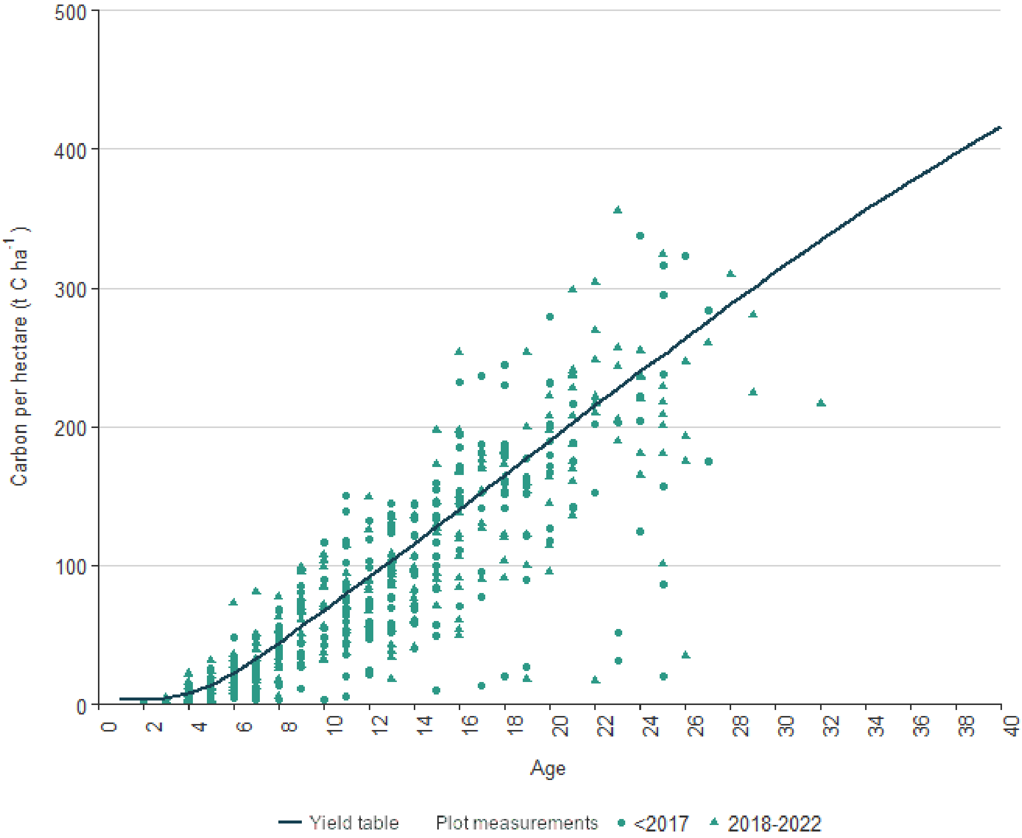
Figure A5.2.15 Carbon stock by age for post-1989 planted forest estimated from the yield table and forest inventory plots



Note: Solid black line – yield table. Circles – plots measured in 2017 or earlier, triangles – plots measured in 2018–22.

The average carbon stock per hectare of measured plots in pre-1990 forest planted after 1990 is 102.4 ± 10.5 tonnes C ha^{-1}. When fitting the adjusted yield table carbon values to the measured plot ages, the average carbon stock per hectare is 113.8 ± 5.6 tonnes C ha^{-1}. On average, the yield table estimates carbon stock per hectare to be 11.4 tonnes C ha^{-1} higher than the measured plot values for these forests. This suggests the yield table for pre-1990 forest planted after 1990 could be overestimating carbon stocks in this forest type over this period. Figure A5.2.16 indicates this could be partially driven by several low-yield plots aged between 15 and 26 that drag the average carbon stock per hectare down.

Figure A5.2.16 Carbon stock by age for pre-1990 planted forest (planted after 1990) estimated from the yield table and forest inventory plots



Note: Solid black line – yield table. Circles – plots measured in 2017 or earlier, triangles – plots measured in 2018–22.

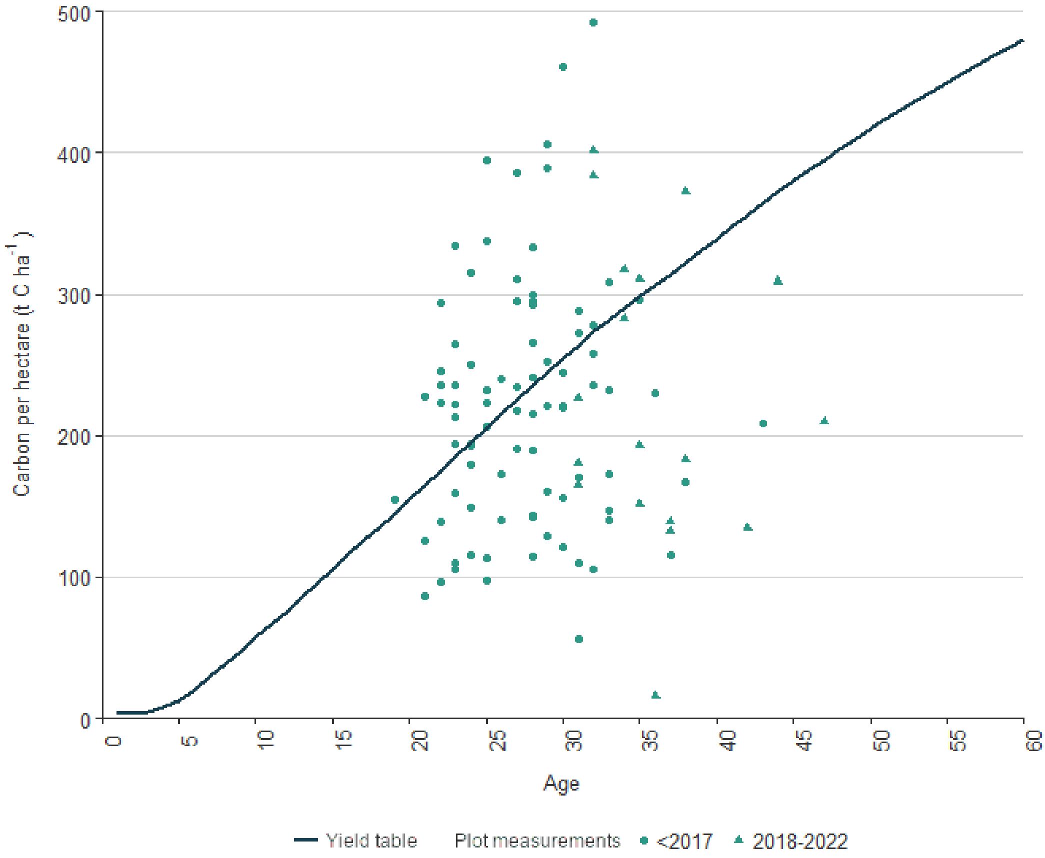
The average carbon stock per hectare of measured plots in pre-1990 forest planted before 1990 is 233.6 ± 47.8 tonnes C ha^{-1}. When fitting the adjusted yield table carbon values to the measured plot ages, the average carbon stock per hectare is 309.5 ± 24.0 tonnes C ha^{-1}. On average, the yield table estimates carbon stock per hectare to be 76.0 tonnes 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 over this period. The large difference between average yield table estimates and measured plot carbon stocks for pre-1990 forest planted before 1990 is likely due to a combination of:

- the small sample size (n=18 plots) (figure A5.2.17) for this forest type, which contributes to uncertainty in average plot carbon stocks in the most recent five-year inventory (2018 to 2022)
- the fact that plots that have since been harvested were also included in the yield table development.

Higher yielding plots were likely prioritised for harvest and, consequently, are less likely to be represented in the 2018 to 2022 forest inventory. Thus, the plots remaining in the 2018 to 2022 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 become available.

Figure A5.2.17 Carbon stock by age for pre-1990 planted forest (planted before 1990) estimated from the yield table and forest inventory plots



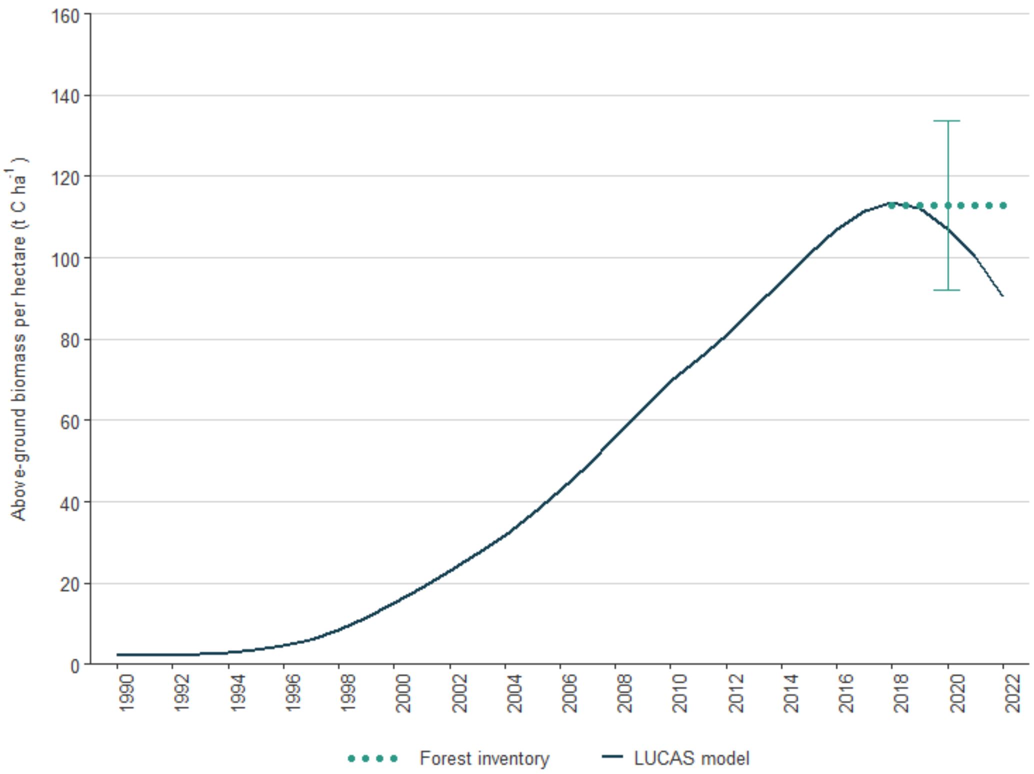
Note: Solid black line – yield table. Circles – plots measured in 2017 or earlier. Triangles – plots measured in 2018–22.

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 with 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 2018 to 2022 forest inventory was 112.9 ± 20.8 tonnes C ha^{-1} (derived from Paul et al., unpublished(e)). This is not very different from the estimated carbon stock per hectare in 2020 (the midpoint of the forest inventory period) generated from the LUCAS CRA model (107.0 tonnes C ha^{-1}) (figure A5.2.18). This suggests the LUCAS CRA model simulation provides 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 A5.2.18 Post-1989 planted forest above-ground biomass carbon per hectare estimated from the 2018 to 2022 forest inventory and LUCAS Calculation and Reporting Application model



Note: Solid black line – LUCAS Calculation and Reporting Application model. Dotted green line – above-ground biomass carbon per hectare estimated from the 2018–22 forest inventory (± 95% confidence interval)

In pre-1990 planted forests, the average above-ground biomass carbon stock per hectare in the 2018 to 2022 forest inventory was 70.3 ± 19.0 tonnes C ha^{-1} (derived from Paul et al., unpublished(e)). This is much lower than the estimated carbon stock per hectare in 2020 generated from the LUCAS CRA model used for this submission (119.4 tonnes C ha^{-1}) (figure A5.2.19). 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.

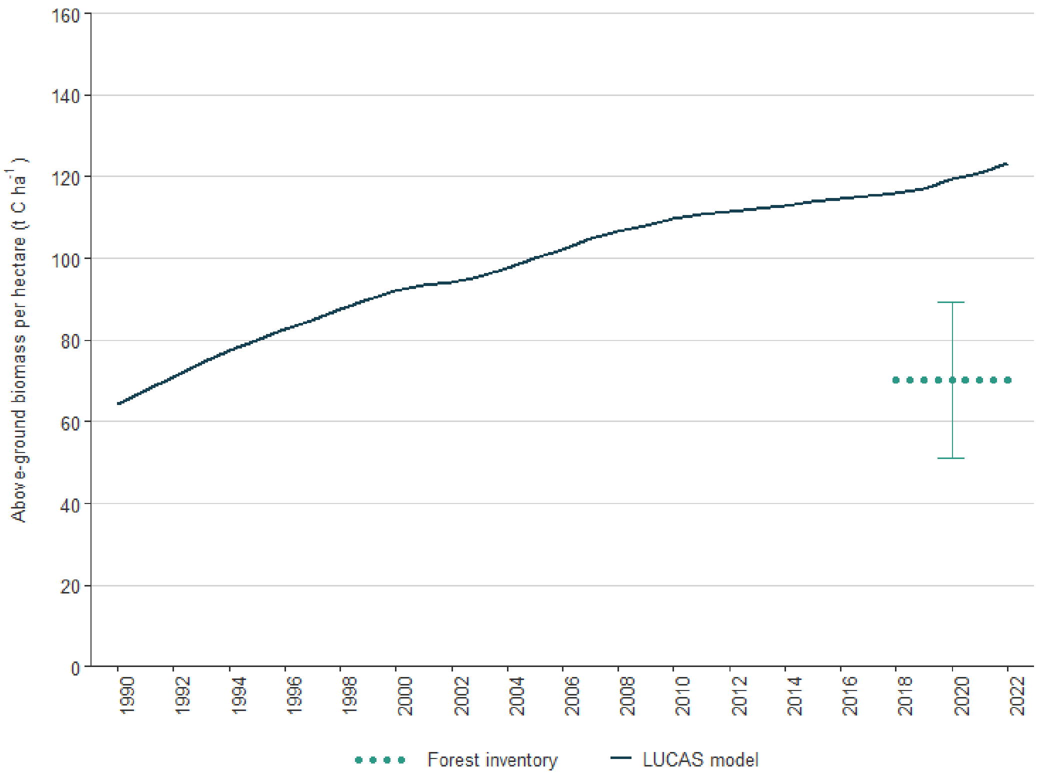
Several factors may contribute to this discrepancy.

1. The carbon stock estimate from the forest inventory (Paul et al., unpublished(e)) assumes all plots that were too young to measure had a carbon stock value of zero. In contrast, the yield tables include carbon stock estimates for these younger stands, which are then used in the LUCAS CRA simulation. Because the pre-1990 planted forest includes a large area of recently harvested forest, this is likely to contribute to the higher carbon stock per hectare estimate of the LUCAS model.
2. A comparison of yield table carbon stocks to plot measurements (table A5.2.14) indicates that the yield tables tend to predict higher carbon stocks than was measured on plots in pre-1990 planted forest. The difference between yield table and plot measurements is slightly more pronounced in older plots (figures A5.2.16 and A5.2.17).
3. A relatively large area of forest older than 40 years is captured in the NEFD and thus also in the LUCAS forest 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 A5.2.14). In comparison, a lower proportion of

plots in this older age group is 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, NEFD 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. Additional validations are presented in Paul et al. (unpublished (e)).

Figure A5.2.19 Pre-1990 planted forest above-ground biomass carbon per hectare, estimated from the 2018 to 2022 forest inventory and LUCAS Calculation and Reporting Application model



Note: Solid black line – LUCAS Calculation and Reporting Application model. Dotted green line – above-ground biomass carbon per hectare estimated from the 2018–22 forest inventory (± 95% confidence interval)

Government initiatives and legislation

Since 1993, the New Zealand Government has introduced legislation and government initiatives to encourage forest establishment and discourage deforestation. These measures are summarised below.

- Climate Change Response Act 2002 (amended 8 December 2009 and 22 June 2020)

  The NZ ETS was introduced under the Climate Change Response Act 2002. *Forest land* was introduced into the scheme on 1 January 2008. Under the scheme, owners of post-1989 forest land have been able to voluntarily participate in the NZ ETS and receive emission units (New Zealand Units (NZUs)) for increases in carbon stocks. Recent participants in the NZ ETS may claim units for increases in carbon stocks from the start of the previous emissions reporting period for the NZ ETS, the most recent of which is 2018. Participants can also claim units annually through a voluntary emissions return.

- Erosion Control Funding Programme

  The Erosion Control Funding Programme, formerly the East Coast Forestry Project, is a grant scheme that was established in 1992. It aimed to address soil erosion on the worst eroding land in the Gisborne District through planting trees or encouraging natural reversion to native bush (Ministry for Primary Industries, 2014). To date, 40,342 hectares of forest have been established under the scheme. This programme was discontinued in 2018 and superseded by the One Billion Trees Programme (see below).

- Permanent Forest Sink Initiative

  The Permanent Forest Sink Initiative enables land owners to earn carbon credits through the establishment of permanent forests on land that was not forested before 1990 (Ministry for Primary Industries, 2015b). In total, 15,584 hectares have been registered under this scheme. In 2018 it was announced that the scheme would be discontinued and replaced by a permanent post-1989 forest category from 1 January 2024.

- Hill Country Erosion Programme

  The Hill Country Erosion Programme, like the Erosion Control Funding Programme, is focused on the retiring and afforestation of erosion-prone, hill-country land. This programme focuses on giving councils additional resourcing to build their technical capability and to give advice to land owners of erosion-prone land, and supports the planting of trees and establishment of forests. It underwent a review in 2011 and continues with an expanded target area throughout erosion-prone land in the North Island (Ministry for Primary Industries, 2015c). To date, 16,289 hectares of plantings have been established under this scheme, of which 5,882 hectares meet the definition of forest land.

- Afforestation Grant Scheme

  The Afforestation Grant Scheme was first established in 2008 to promote carbon sequestration, reduce soil erosion and improve water quality. The first round of the scheme established 9,343 hectares of new forest between 2008 and 2013. A second afforestation grant scheme was established in 2015, and 7,846 hectares of new forest were established under this scheme (Ministry for Primary Industries, 2018). The scheme was replaced by the One Billion Trees Programme in 2018.

- One Billion Trees Programme

  The One Billion Trees Programme was established in 2018 to support individuals and groups across New Zealand to plant trees and manage land sustainably. Te Uru Rākau works in partnership with land owners and organisations to achieve the goal of planting 1 billion trees by 2028. Since the programme was announced, up to late 2023 626,937,000 trees have been planted (Te Uru Rākau, 2023).

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 (tables A5.2.15 to A5.2.18).

Table A5.2.15 Pre-1990 natural forest – tall forest carbon stocks by year (tonnes C ha^{-1})

Year	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
1990	145.1	34.0	44.0	22.2	245.4
1991	145.1	34.0	44.0	22.2	245.4
1992	145.1	34.0	44.0	22.2	245.4
1993	145.1	34.0	44.0	22.2	245.4
1994	145.1	34.0	44.1	22.2	245.4
1995	145.1	34.0	44.1	22.2	245.4
1996	145.0	34.0	44.1	22.2	245.4
1997	145.0	34.0	44.1	22.2	245.4
1998	145.0	34.0	44.1	22.2	245.4
1999	145.0	34.0	44.1	22.2	245.3
2000	145.0	34.0	44.1	22.2	245.3
2001	145.0	34.0	44.1	22.2	245.3
2002	145.0	34.0	44.1	22.2	245.3
2003	144.9	34.0	44.1	22.2	245.3
2004	144.9	34.0	44.1	22.2	245.3
2005	144.9	34.0	44.1	22.2	245.3
2006	144.9	34.0	44.1	22.2	245.3
2007	144.9	34.0	44.2	22.2	245.3
2008	144.9	34.0	44.2	22.2	245.2
2009	144.9	34.0	44.2	22.2	245.2
2010	144.8	34.0	44.2	22.2	245.2
2011	144.8	34.0	44.2	22.2	245.2
2012	144.8	34.0	44.2	22.2	245.2
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
2021	144.7	33.9	44.3	22.2	245.1
2022	144.7	33.9	44.3	22.2	245.1

Note: Data derived from Paul et al. (2021).

Table A5.2.16 Pre-1990 natural forest – regenerating forest carbon stocks by year (tonnes C ha^{-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	37.0	8.9	10.3	9.7	65.8
1999	37.3	8.9	10.2	9.7	66.2
2000	37.7	9.0	10.2	9.7	66.6
2001	38.0	9.1	10.2	9.7	67.0

Year	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
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	70.0
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	10.0	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	43.0	10.3	10.1	9.7	73.0
2016	43.4	10.4	10.0	9.7	73.5
2017	43.7	10.4	10.0	9.7	73.9
2018	44.1	10.5	10.0	9.7	74.3
2019	44.4	10.6	10.0	9.7	74.7
2020	44.8	10.7	10.0	9.7	75.2
2021	45.2	10.8	10.0	9.7	75.6
2022	45.5	10.9	10.0	9.7	76.0

Note: Data derived from Paul et al. (2021).

Table A5.2.17 Post-1989 natural forest yield table (tonnes C ha^{-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

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
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
31	65.2	16.3	0.2	0.9	82.7
32	66.1	16.5	0.2	0.9	83.8

Note: Yield table data derived from Paul et al. (unpublished(b)).

Table A5.2.18 Post-1989 natural forest yield table (tonnes C ha^{-1}) (for transitions from *Grassland with woody biomass*)

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
0	9.3	3.0	0.1	0.6	13.0
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	27.0
9	22.5	6.2	0.1	0.6	29.5
10	24.6	6.7	0.1	0.6	32.0
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	43.0
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	47.0	12.0	0.2	0.8	59.9
21	49.1	12.5	0.2	0.8	62.6
22	51.2	13.0	0.2	0.8	65.2
23	53.2	13.5	0.2	0.8	67.7
24	55.2	13.9	0.2	0.8	70.1
25	57.0	14.3	0.2	0.8	72.3
26	58.7	14.7	0.2	0.8	74.5
27	60.3	15.1	0.2	0.8	76.4
28	61.7	15.5	0.2	0.8	78.2
29	63.0	15.8	0.2	0.9	79.9
30	64.1	16.0	0.2	0.9	81.3
31	65.1	16.3	0.2	0.9	82.5
32	65.8	16.4	0.2	0.9	83.4

Note: Yield table data derived from Paul et al. (unpublished(b)).

Planted forest yield tables

This section contains the planted forest yield tables used for this submission (tables A5.2.19 to A5.2.21).

Table A5.2.19 Pre-1990 'planted before 1990' planted forest yield table (tonnes C ha^{-1})

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
0	2.4	0.6	0.1	0.0	3.1
1	2.6	0.7	0.1	0.0	3.3
2	3.0	0.8	0.1	0.0	3.9
3	4.3	1.2	0.1	0.1	5.8
4	7.1	2.0	0.1	0.5	9.7
5	11.4	3.1	0.2	1.3	16.0
6	16.8	4.3	0.5	2.6	24.2
7	22.1	5.4	1.5	4.6	33.6
8	26.7	6.4	3.3	6.9	43.2
9	32.4	7.6	4.2	8.2	52.4
10	39.3	9.0	4.5	8.8	61.6
11	45.3	10.2	5.9	9.7	71.2
12	52.1	11.6	6.9	10.0	80.6
13	60.4	13.3	6.6	9.8	90.1
14	68.6	15.0	6.8	9.7	100.1
15	76.7	16.7	7.2	9.7	110.2
16	84.0	18.1	8.6	9.8	120.5
17	91.6	19.7	9.5	9.7	130.5
18	100.1	21.4	9.0	9.5	140.0
19	108.6	23.1	8.7	9.3	149.6
20	117.6	25.0	8.2	8.9	159.7
21	126.5	26.9	7.9	8.6	169.9
22	135.3	28.8	7.7	8.4	180.1
23	144.2	30.7	7.4	8.1	190.5
24	152.9	32.5	7.4	8.0	200.8
25	161.3	34.4	7.5	7.8	211.0
26	169.5	36.1	7.6	7.7	220.9
27	177.6	37.9	7.6	7.6	230.6
28	185.2	39.6	7.9	7.5	240.2
29	192.8	41.2	8.2	7.5	249.7
30	200.9	43.0	8.0	7.4	259.2
31	209.0	44.8	7.8	7.2	268.9
32	216.5	46.4	7.7	7.2	277.8
33	223.2	47.9	7.8	7.1	286.1
34	229.9	49.5	7.8	7.0	294.2
35	236.5	50.9	7.8	7.0	302.2
36	242.8	52.4	7.9	6.9	309.9
37	249.2	53.9	7.9	6.8	317.8
38	256.2	55.5	8.0	6.6	326.2
39	263.2	57.1	8.0	6.5	334.9
40	270.2	58.8	8.1	6.4	343.5
41	277.0	60.4	8.2	6.3	351.9
42	283.7	61.9	8.4	6.2	360.3
43	290.1	63.5	8.6	6.2	368.4
44	296.4	65.0	8.8	6.1	376.2
45	302.4	66.5	9.0	6.0	383.9

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
46	308.4	67.9	9.2	5.9	391.4
47	314.2	69.4	9.5	5.8	398.8
48	319.9	70.8	9.7	5.7	406.1
49	325.4	72.2	10.0	5.6	413.2
50	330.9	73.6	10.2	5.5	420.2
51	336.2	74.9	10.4	5.5	427.0
52	341.4	76.3	10.7	5.4	433.7
53	346.5	77.6	10.9	5.3	440.3
54	351.5	78.9	11.2	5.2	446.7
55	356.3	80.2	11.4	5.2	453.1
56	361.1	81.4	11.6	5.1	459.3
57	365.8	82.7	11.8	5.0	465.4
58	370.5	83.9	12.1	4.9	471.4
59	375.0	85.1	12.3	4.9	477.3
60	379.5	86.4	12.5	4.8	483.1

Note: Yield table data derived from Paul et al. (unpublished(e)).

Table A5.2.20 Pre-1990 'planted 1990 onwards' planted forest yield table (tonnes C ha^{-1})

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
0	2.6	0.6	0.2	0.0	3.4
1	2.8	0.7	0.2	0.0	3.7
2	3.2	0.8	0.2	0.0	4.3
3	4.6	1.3	0.2	0.1	6.3
4	7.8	2.1	0.2	0.5	10.6
5	12.7	3.3	0.3	1.2	17.5
6	19.1	4.8	0.4	2.5	26.8
7	26.4	6.3	0.9	4.2	37.8
8	33.9	7.9	1.7	6.2	49.7
9	41.7	9.4	2.7	8.0	61.8
10	50.1	11.2	3.3	9.2	73.7
11	59.0	13.0	3.7	9.9	85.6
12	68.1	14.8	4.2	10.4	97.6
13	77.7	16.8	4.5	10.6	109.5
14	87.4	18.7	4.9	10.7	121.7
15	97.4	20.8	5.1	10.7	134.0
16	108.0	23.0	5.0	10.5	146.4
17	118.6	25.2	4.9	10.2	159.0
18	129.1	27.4	5.0	10.0	171.5
19	139.4	29.6	5.1	9.8	184.0
20	149.7	31.8	5.3	9.6	196.4
21	159.8	34.0	5.5	9.4	208.8
22	169.8	36.2	5.9	9.3	221.2
23	179.4	38.4	6.6	9.2	233.5
24	188.9	40.5	7.3	9.1	245.8
25	198.6	42.7	7.7	8.9	257.9
26	208.2	44.9	8.2	8.8	270.0
27	217.6	47.1	8.7	8.7	282.1
28	227.0	49.2	9.3	8.6	294.0
29	236.1	51.4	9.9	8.5	305.8
30	245.0	53.5	10.5	8.4	317.4
31	253.7	55.6	11.1	8.3	328.8

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
32	262.2	57.7	11.8	8.2	340.0
33	270.5	59.7	12.5	8.1	350.9
34	278.6	61.7	13.2	8.1	361.6
35	286.5	63.7	13.9	8.0	372.0
36	294.1	65.6	14.6	7.9	382.3
37	301.6	67.6	15.3	7.8	392.3
38	309.0	69.5	16.0	7.7	402.1
39	316.2	71.4	16.7	7.6	411.8
40	323.2	73.3	17.3	7.5	421.3
41	330.1	75.1	18.0	7.5	430.6
42	336.8	76.9	18.6	7.4	439.6
43	343.2	78.6	19.2	7.3	448.4
44	349.5	80.4	19.8	7.2	456.9
45	355.6	82.1	20.4	7.1	465.2
46	361.5	83.8	20.9	7.0	473.2
47	367.2	85.4	21.5	7.0	481.0
48	372.8	87.0	21.9	6.9	488.6
49	378.3	88.6	22.4	6.8	496.0
50	383.6	90.2	22.9	6.7	503.3
51	388.8	91.7	23.3	6.6	510.3
52	393.8	93.2	23.7	6.5	517.2
53	398.8	94.7	24.0	6.4	524.0
54	403.6	96.2	24.4	6.3	530.6
55	408.4	97.7	24.7	6.2	537.0
56	413.1	99.1	25.0	6.2	543.3
57	417.7	100.5	25.3	6.1	549.6
58	422.2	101.9	25.5	6.0	555.7
59	426.6	103.3	25.7	6.0	561.7
60	431.1	104.7	26.0	5.9	567.7

Note: Yield table data derived from Paul et al. (unpublished(e)).

Table A5.2.21 Post-1989 planted forest yield table (tonnes C ha^{-1})

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
0	2.1	0.5	0.2	0.0	2.8
1	2.3	0.6	0.2	0.0	3.1
2	3.0	0.7	0.2	0.0	3.9
3	4.3	1.3	0.2	0.1	6.0
4	7.3	2.5	0.2	0.4	10.5
5	13.0	3.8	0.3	1.2	18.3
6	20.7	5.1	0.8	2.9	29.5
7	27.6	6.5	1.9	5.2	41.3
8	33.2	7.6	3.6	7.7	52.2
9	37.7	8.5	6.2	10.0	62.4
10	42.1	9.4	8.6	11.6	71.7
11	48.0	10.7	9.7	12.1	80.5
12	55.7	12.2	9.7	11.9	89.6
13	64.4	14.0	9.4	11.6	99.4
14	73.5	15.9	9.1	11.3	109.8
15	82.9	17.8	8.7	11.0	120.4
16	92.3	19.7	8.4	10.6	131.1
17	101.9	21.6	8.2	10.3	142.0

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
18	111.5	23.6	8.0	10.0	153.1
19	120.9	25.6	7.8	9.8	164.1
20	130.2	27.5	7.7	9.5	174.9
21	139.4	29.4	7.5	9.2	185.5
22	148.5	31.4	7.3	8.9	196.1
23	157.6	33.4	7.1	8.7	206.7
24	166.8	35.3	6.9	8.5	217.6
25	176.0	37.3	6.9	8.3	228.5
26	185.1	39.3	6.9	8.2	239.5
27	194.2	41.3	6.8	8.0	250.3
28	203.2	43.3	6.8	7.8	261.1
29	212.1	45.3	6.8	7.6	271.8
30	220.8	47.3	6.9	7.4	282.4
31	229.4	49.2	7.1	7.2	293.0
32	237.7	51.2	7.3	7.2	303.3
33	245.9	53.1	7.5	7.0	313.5
34	253.9	54.9	7.9	7.0	323.7
35	261.6	56.8	8.4	7.0	333.8
36	269.2	58.6	8.9	6.9	343.6
37	276.7	60.4	9.3	6.8	353.2
38	284.0	62.2	9.7	6.8	362.6
39	291.1	63.9	10.1	6.7	371.9
40	298.2	65.7	10.6	6.6	381.0
41	305.0	67.4	11.0	6.5	389.9
42	311.7	69.1	11.4	6.5	398.7
43	318.3	70.7	11.8	6.4	407.2
44	324.6	72.3	12.3	6.3	415.5
45	330.7	73.9	12.7	6.2	423.6
46	336.7	75.5	13.1	6.2	431.4
47	342.6	77.0	13.5	6.1	439.1
48	348.2	78.5	13.8	6.0	446.6
49	353.8	80.0	14.2	5.9	453.9
50	359.2	81.4	14.6	5.8	461.0
51	364.4	82.9	14.9	5.8	468.0
52	369.6	84.3	15.3	5.7	474.8
53	374.6	85.7	15.6	5.6	481.5
54	379.6	87.1	15.9	5.5	488.0
55	384.4	88.4	16.2	5.4	494.4
56	389.2	89.7	16.4	5.4	500.8
57	393.9	91.1	16.7	5.3	506.9
58	398.5	92.4	17.0	5.2	513.0
59	403.0	93.7	17.2	5.2	519.0
60	407.4	94.9	17.4	5.1	524.9

Note: Yield table data derived from Paul et al. (unpublished(e)).

A5.2.6 Harvested wood products

Domestic market raw material – market activity data and half-lives

The weighted half-lives applied to sawnwood and wood panels processed from domestic roundwood consumption and consumed in end-uses in the domestic and export market are calculated from the sub-product lifetimes (Ministry for Primary Industries, 2022; Wakelin, unpublished(i); Wekesa, 2022). Sub-product half-lives and their proportions for each domestic and export market are summarised in tables A5.2.22 and A5.2.23 based on data collected in 2019 and 2021.

Table A5.2.22 *Harvested wood products* type, domestic market roundwood logs volume in 2022 and assumed half-lives for New Zealand

Product	Sub-product	Volume (million m^3)	Half-life
PANEL	Plywood – construction	0.0378075	50.3
PANEL	Plywood – formwork	0.0074415	1
PANEL	Plywood – other	0.0297655	34.7
PANEL	LVL – construction	0.117039	50.3
PANEL	LVL – formwork	0.02926	1
PAPER	MDF – floors/ceilings	0.152676	29.1
PANEL	MDF – other	0.039207	18.2
PANEL	Particleboard – floors/ceilings	0.0481835	30.2
PANEL	Particle board – other	0.0441295	20.7
SAWN	Construction	1.2372765	50.3
SAWN	Outdoor	0.5025485	31.6
SAWN	Packaging	0.4640485	4.5
SAWN	Joinery	0.1518405	22.9
SAWN	Decking	0.153859	23.9
SAWN	Furniture	0.07257	15.2
SAWN	Formwork	0.0535145	1

Table A5.2.23 *Harvested wood products* type, exported HWP volume in 2022 and assumed half-lives in the export markets

Product	Sub-product	Volume (million m^3)	Half-life
PANEL	Plywood – construction	0.011834	62.4
PANEL	Plywood – formwork	0.002367	0.7
PANEL	Plywood – other	0.009467	34.7
PANEL	LVL – construction	0.009467	62.4
PANEL	LVL – formwork	0.010751	0.7
PAPER	MDF – floors	0.0461	34.7
PANEL	MDF – built-ins	0.108038	17.3
PANEL	MDF – door	0.106167	24.3
PANEL	MDF – kitchen/bathroom cabinets	0.106167	13.9
PANEL	MDF – window	0.05961	17.3
PANEL	MDF – other	0.104753	10.8
PANEL	Particle board – wall/ceilings	0.011299	34.7
PANEL	Particle board – other	0.0555395	28.2
SAWN	Construction	0.493773	62.4
SAWN	Outdoor	0.02192	31.6

Product	Sub-product	Volume (million m³)	Half-life
SAWN	Packaging	0.738288	4.5
SAWN	Joinery	0.368405	22.9
SAWN	Decking	0.004885	23.9
SAWN	Furniture	0.452825	15.2
SAWN	Formwork	0.048168	1

Export raw material – 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 the 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 A5.2.24 to A5.2.26 based on data collected in 2015.

Table A5.2.24 ***Harvested wood products*** **type, waste and fuel product type, exported volume in 2015 and assumed half-lives for China**

Product	Sub-product	Waste/fuel product	Volume (million m³)	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 A5.2.25 ***Harvested wood products*** **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 m³)	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

Product	Sub-product	Waste/fuel product	Volume (million m^3)	Half-life
PANEL	Slabwood	MDF	0.526	25
–	Sawdust	Agriculture	0.1841	0
–	–	Burned	0.0526	0
PANEL	MDF	–	0.0526	25

Table A5.2.26 ***Harvested wood products*** **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

A5.2.7 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 events and data collected on 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-carbon dioxide (CO_2) emissions from wildfire in the *Forest land remaining forest land* category. Wildfire activity data were attributed to each category by the proportion of forest type estimated to be burned over the time series until 2007. For 2007 to 2016, area data available in the wildfire database were split into natural and planted forests (Wakelin, unpublished(d)). The split before 2007 assumed 87.5 per cent to be planted forest and the remainder to be natural forest (Wakelin, unpublished(g)). The planted forest activity data were 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 in section A5.2.5, 'National forest inventory'.

From 2017 onwards, Fire and Emergency New Zealand has supplied mapped wildfire activity data. This has enabled the use of the land use map to infer the type of land cover and category of forest burned. Consequently, since 2017 areas of pre-1990 and post-1989 planted and natural forest affected by wildfire are now derived from the land use map. For planted forest, it is still 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)) and these estimates are again derived from the national forest plot network (section A5.2.5, 'National forest inventory'). For natural forest, it is assumed that the carbon stock of the mapped area affected by wildfire is equivalent to the weighted average carbon stock for that forest type.

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 (Wakelin, unpublished(e)). 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, 2006b).

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 vegetation 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, 2006b).

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).

A5.2.8 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 category. For the LULUCF sector, all uncertainties are combined using approach 1 in the IPCC 2006 General Guidance and Reporting: the propagation of error (IPCC, 2006c).

Methods used to calculate uncertainty in *Forest land*

Uncertainty in net CO_2 emissions from *Forest land* is 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, ±12.3 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 A5.2.4, '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 given for each forest type 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 2022 are estimated to be 76.0 ± 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 ± 27.2 per cent and ± 21.0 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, 2006c). 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 include an additional component of 20.0 per cent uncertainty in the 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 ± 0.19 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 A5.2.27.

Table A5.2.27 Uncertainty in New Zealand's 2022 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	±21.0
Uncertainty in regenerating forest biomass carbon stocks	±27.2
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	**±18.7**

Note: Land area includes land in transition in 2022. 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, 2006c).

Post-1989 natural forest

The average carbon stock in post-1989 natural forest at the point of the most recent plot measurements (2019) was estimated to be 38.55 ± 10.23 tonnes C ha^{-1}. The associated uncertainty in 2022 is ±27.0 per cent. The average carbon stock change in post-1989 natural forest at the most recent plot measurements (2019) was estimated to be 2.48 ± 1.1 tonnes C ha^{-1} yr^{-1}, with an associated uncertainty in 2022 of ±44.8 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 this inventory submission is provided in table A5.2.28.

Table A5.2.28 Uncertainty in New Zealand's 2022 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	**±1.3**

Note: Land area includes land in transition in 2022. 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, 2006c).

Pre-1990 planted forest

The uncertainty in carbon losses applied to New Zealand's pre-1990 planted forest biomass carbon stocks is ±20.7 per cent at the 95 per cent confidence interval, while the uncertainty in carbon stock change (carbon gains) is ±11.9 per cent (table A5.2.29). 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 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 this submission is provided in table A5.2.29.

Table A5.2.29 Uncertainty in New Zealand's 2022 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)	±20.7
Uncertainty in planted forest biomass carbon stock change (gains)	±11.9
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	**±53.0**

Note: Land area includes land in transition in 2022. 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, 2006c). LULUCF = Land Use, Land-use Change and Forestry.

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 (table A5.2.30). 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 this inventory submission is provided in table A5.2.30.

Table A5.2.30 Uncertainty in New Zealand's 2022 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)	±9.6
Uncertainty in unstocked forest biomass carbon stocks	±72.0

Variable	Uncertainty at a 95% confidence interval (%)
Uncertainty in riparian forest biomass carbon stocks	±75.0
Uncertainty in soil carbon stocks	±10.4
Uncertainty introduced into net emissions for LULUCF	**±19.5**

Note: Land area includes land in transition in 2022. 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, 2006c). LULUCF = Land Use, Land-use Change and Forestry.

Methods used to calculate uncertainty in *Cropland*

The uncertainty in mapping *Cropland* is ±8.0 per cent (table A5.2.31).

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, 2006b). 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 (table A5.2.31). Uncertainties in soil carbon stock change are calculated for each specific land use transition (section A5.2.4, ‘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, 2006b).

As shown in table A5.2.31, 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 A5.2.31 Uncertainty in New Zealand’s 2022 carbon estimates for the *Cropland* category (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	**±2.1**	**±0.5**

Note: LULUCF = Land Use, Land-use Change and Forestry.

Methods used to calculate uncertainty in *Grassland*

The uncertainty in mapping *Grassland* is ±8.0 per cent for *High producing* and *Low producing grassland* and ±83.0 per cent for *Grassland with woody biomass* (table A5.2.32).

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, 2006b). 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 *Grassland 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 for *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 (table A5.2.32). Uncertainties in soil carbon stock change are calculated for each specific land use transition (section A5.2.4, '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, 2006b).

Table A5.2.32 Uncertainty in New Zealand's 2022 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	**±1.0**	**±5.9**	**±1.8**

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.
LULUCF = Land Use, Land-use Change and Forestry.

Methods used to calculate uncertainty in *Wetlands*

The uncertainty in mapping *Wetlands* is ±33.0 per cent (table A5.2.33).

The uncertainty associated with biomass losses on conversion to *Wetlands* is calculated from the carbon stocks in the from land use category. A New Zealand-specific value derived from a recent literature review (Easdale et al., unpublished) is used for biomass accumulation in vegetated wetlands. There is assumed to be no gain in carbon biomass on conversion to open water wetlands.

The uncertainty for mineral SOC stocks in vegetated wetlands is ±12.3 per cent. An estimated uncertainty of ±90.0 per cent is used for mineral SOC stocks in open water wetlands. Uncertainties in soil carbon stock change on conversion to and from vegetated wetlands are calculated for each specific land use transition (section A5.2.4, '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 A5.2.4, '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, 2006b).

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

Table A5.2.33 Uncertainty in New Zealand's 2022 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	±150.0	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**	**±0.1**

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, 2006c). LULUCF = Land Use, Land-use Change and Forestry.

Methods used to calculate uncertainty in *Settlements*

The uncertainty in mapping *Settlements* is ±22.0 per cent (table A5.2.34).

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 mineral 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 A5.2.4, 'Mineral soils').

Table A5.2.34 Uncertainty in New Zealand's 2022 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	**±0.4**

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, 2006c). LULUCF = Land Use, Land-use Change and Forestry.

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 of ±70.7, as calculated from the Tier 2 method estimates of SOC (table A5.2.35). Uncertainties in soil carbon stock change on conversion to and from *Other land* are calculated for each specific land use transition (section A5.2.4, 'Mineral soils').

Table A5.2.35 Uncertainty in New Zealand's 2022 carbon estimates for *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	**±0.4**

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, 2006c). LULUCF = Land Use, Land-use Change and Forestry.

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, 2006c).

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 products* 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. Uncertainties for *Harvested wood products* activity data and parameters are given in table A5.2.36. Uncertainty in New Zealand's 2022 carbon estimates from emissions associated with *Harvested wood products* is provided in table A5.2.37.

Table A5.2.36 Uncertainty in *Harvested wood products* data and parameters

Parameter	% uncertainty	Origin
Harvested wood products production, import and export data	±15.0	IPCC default (table 12.6, IPCC, 2006b)
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 A5.2.37 Uncertainty in New Zealand's 2022 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	±91.9
Total domestically milled and exported products uncertainty	±68.2
Uncertainty introduced into net emissions for LULUCF	**±23.3**

Note: LULUCF = Land Use, Land-use Change and Forestry.

Methods used to calculate uncertainty for nitrous oxide emissions from soils

Uncertainties for direct N_2O emission factors associated with drainage, as well as indirect N_2O emissions from leaching and runoff, are sourced from chapter 11 of the IPCC 2006 Guidelines (IPCC, 2006b). Tables 11.1 and 11.3 of the 2006 IPCC Guidelines give an uncertainty range. The relative uncertainty is then adjusted using the approach for dealing with asymmetric uncertainties, as described by equations 3.3 and 3.4 in Chapter 3 of the IPCC General Guidance and Reporting (IPCC, 2006c). 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 A5.2.38.

Table A5.2.38 Uncertainty in New Zealand's 2022 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	±24.0
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	**±0.7**

Note: C:N = carbon:nitrogen. LULUCF = Land Use, Land-use Change and Forestry.

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 A5.2.39.

Table A5.2.39 Uncertainty analysis for the LULUCF sector

IPCC category	Gas	1990 emissions or removals (kt CO_2-e)	2022 emissions or removals (kt CO_2-e)	Activity data uncertainty (%)	Emission factor / estimation parameter uncertainty (biomass) (%)	Combined uncertainty (%)	Contribution to variance by category in 2022	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	-1,363.5	-1,440.1	0.0	250.2	250.2	0.035	1.5	5.9	3.7	0.0	0.1
Pre-1990 planted forest	CO_2	-22,323.8	-12,614.1	0.0	80.9	80.9	0.281	20.5	51.9	16.6	0.0	2.8
Post-1989 planted forest	CO_2	163.8	-2,759.2	0.0	163.1	163.1	0.055	11.9	11.3	19.4	0.0	3.8
Post-1989 natural forest	CO_2	3.8	-719.2	0.0	35.4	35.4	0.000	3.0	3.0	1.1	0.0	0.0
Cropland perennial	CO_2	126.1	62.2	0.0	148.3	148.3	0.000	0.2	0.3	0.2	0.0	0.0
Cropland annual	CO_2	343.5	625.1	0.0	64.0	64.0	0.000	1.5	2.6	0.9	0.0	0.0
Grassland low producing	CO_2	167.1	2,261.9	0.0	50.4	50.4	0.004	8.8	9.3	4.4	0.0	0.2
Grassland high producing	CO_2	466.7	871.4	0.0	21.5	21.5	0.000	2.1	3.6	0.4	0.0	0.0
Grassland with woody biomass	CO_2	76.0	490.4	0.0	70.5	70.5	0.000	1.8	2.0	1.2	0.0	0.0
Wetlands – open water	CO_2	-17.8	-4.9	0.0	258.3	258.3	0.000	0.0	0.0	0.1	0.0	0.0
Wetlands – vegetative non-forest	CO_2	0.1	-5.1	0.0	39.1	39.1	0.000	0.0	0.0	0.0	0.0	0.0
Wetlands – vegetative 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	78.9	118.0	0.0	65.5	65.5	0.000	0.2	0.5	0.1	0.0	0.0
Other land	CO_2	14.6	87.0	0.0	28.6	28.6	0.000	0.3	0.4	0.1	0.0	0.0
Harvested wood products	CO_2	-2,437.8	-6,582.3	0.0	68.2	68.2	0.055	19.1	27.1	13.0	0.0	1.7
Direct N_2O emissions from N mineralisation/immobilisation	N_2O	165.0	104.5	8.0	84.9	85.2	0.000	0.1	0.4	0.1	0.0	0.0
Direct N_2O emissions from drainage and rewetting	N_2O	67.0	98.1	33.0	80.0	86.5	0.000	0.2	0.4	0.1	0.1	0.0

IPCC category	Gas	1990 emissions or removals (kt CO_2-e)	2022 emissions or removals (kt CO_2-e)	Activity data uncertainty (%)	Emission factor / estimation parameter uncertainty (biomass) (%)	Combined uncertainty (%)	Contribution to variance by category in 2022	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	37.1	23.5	8.0	126.5	126.7	0.000	0.0	0.1	0.0	0.0	0.0
N_2O emissions from biomass burning	N_2O	22.8	43.7	30.0	41.7	51.4	0.000	0.1	0.2	0.0	0.0	0.0
CH_4 emissions from biomass burning	CH_4	76.6	82.3	30.0	41.7	51.4	0.000	0.1	0.3	0.0	0.0	0.0
Total		**-24,324.8**	**-19,238.8**			**Total uncertainty (%)**	**65.6**				**Total uncertainty in trend (%)**	**29.3**

Note: LULUCF = Land Use, Land-use Change and Forestry.

A5.2.9 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 Paris Agreement (figure A5.2.20).

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

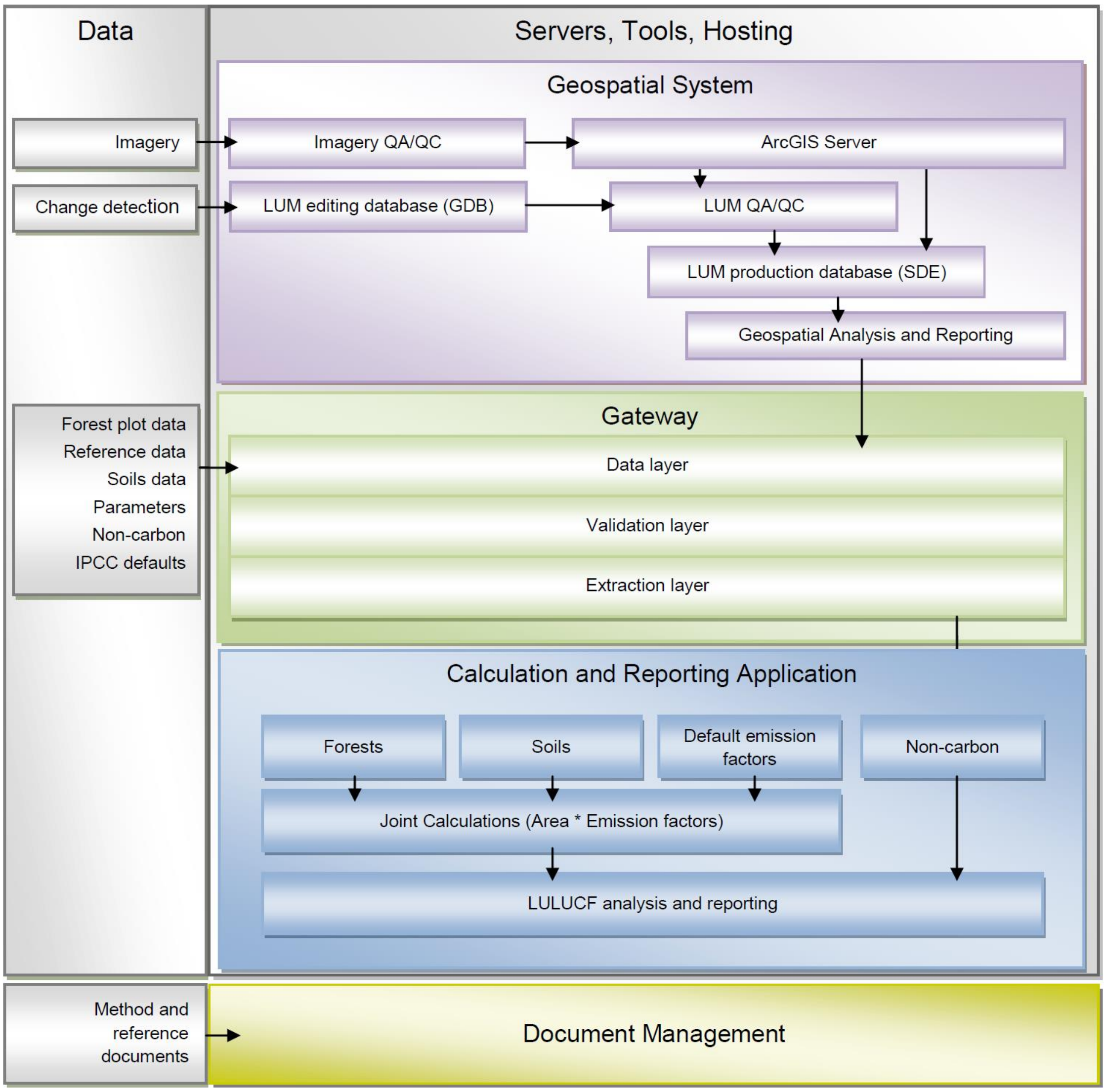
The main objectives of these systems are to:

- 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 Paris Agreement
- 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.

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 A5.2.20 New Zealand's LUCAS data management system

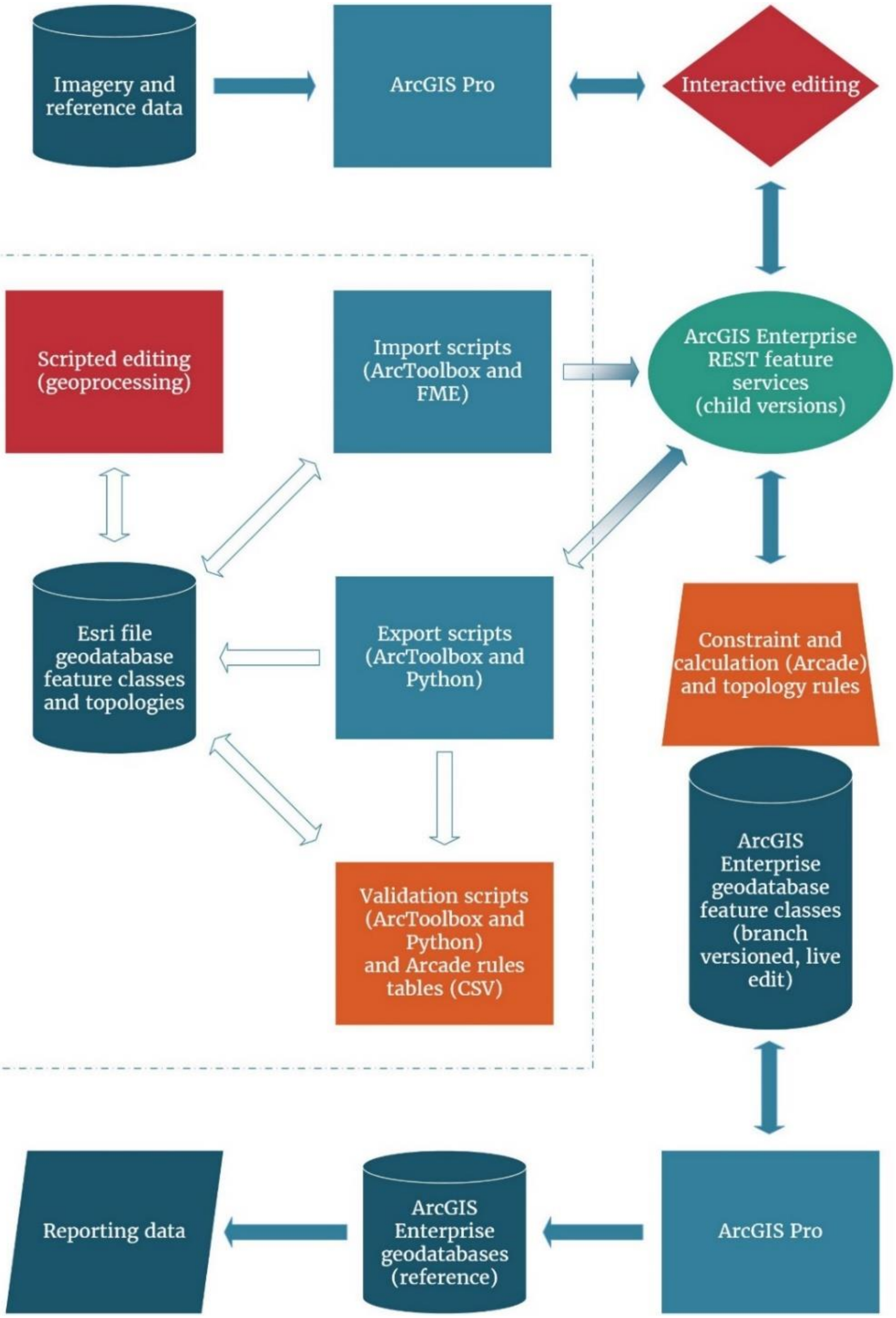


Note: IPCC = Intergovernmental Panel on Climate Change; LULUCF = Land Use, Land-Use Change and Forestry; LUM = land use map; QA/QC = quality assurance/quality control. Joint calculations are described below.

Geospatial System

The Geospatial System consists of applications and virtualised infrastructure customised to meet LULUCF reporting requirements. The infrastructure comprises a variety of file/object storage, relational databases, and servers supporting spatial data storage, management, versioning and running of web services for mapping. The core components of the Geospatial System are outlined in figure A5.2.21.

Figure A5.2.21 New Zealand's Geospatial System components



Land use mapping functionality

The LUCAS New Zealand land use map (LUM) is made up of several spatial data sets including the Chatham Islands and the other offshore islands within New Zealand's Exclusive Economic Zone. For accuracy, these islands are mapped and stored in their own separate NZGD2000 map projections but are combined statistically for reporting purposes.

The LUM is designed to represent land use and confirmed land-use change at each of the mapping dates of 1989, 2007, 2012 and 2016. It is also necessary to track unconfirmed change that is detected in parallel maps (e.g., forest destocking) until the land use intention is confirmed and the change can be integrated into the LUM.

A variety of coded scripts (functioning as tools) is used to harness the Esri ArcGIS suite to manage and validate the integrity of these data sets. As the version of the ArcGIS suite is upgraded, the scripts are recompiled as required. Where coded scripts are not present, carefully documented manual processes are used to structure and manage the data sets.

Manual editing of the maps is typically carried out via branch versioned Esri REST web feature services with coded calculation and constraint rules active. These rules ensure that attribution is consistent and complete, which includes ensuring that the sequences of land-use change mapped are valid.

The system allows multiple editors to have concurrent access from anywhere with internet, providing resilience during map production and the ability to scale mapping teams as required.

To accommodate scripted edits, these maps are exported from their respective feature services to Esri file geodatabase(s) with rules disabled, are processed, and then are scanned for topology and attribute validity before being re-imported into child versions within the services.

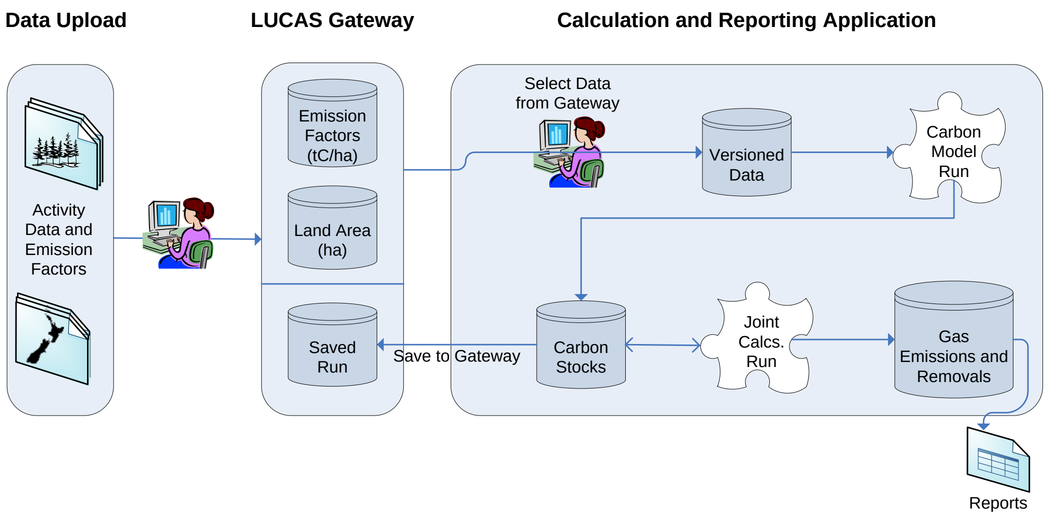
Production spatial data sets are stored in Esri ArcGIS Enterprise geodatabases. Some databases are used for reference and others for supporting web services.

The archive of remote sensing data, from which the LUCAS land-use change detection is derived, is structured and maintained in cloud-based object storage. Its metadata are managed centrally in ArcGIS Enterprise geodatabases.

LUCAS Management Studio

The LUCAS Management Studio (figure A5.2.22) 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 A5.2.22 LUCAS Management Studio



LUCAS Gateway

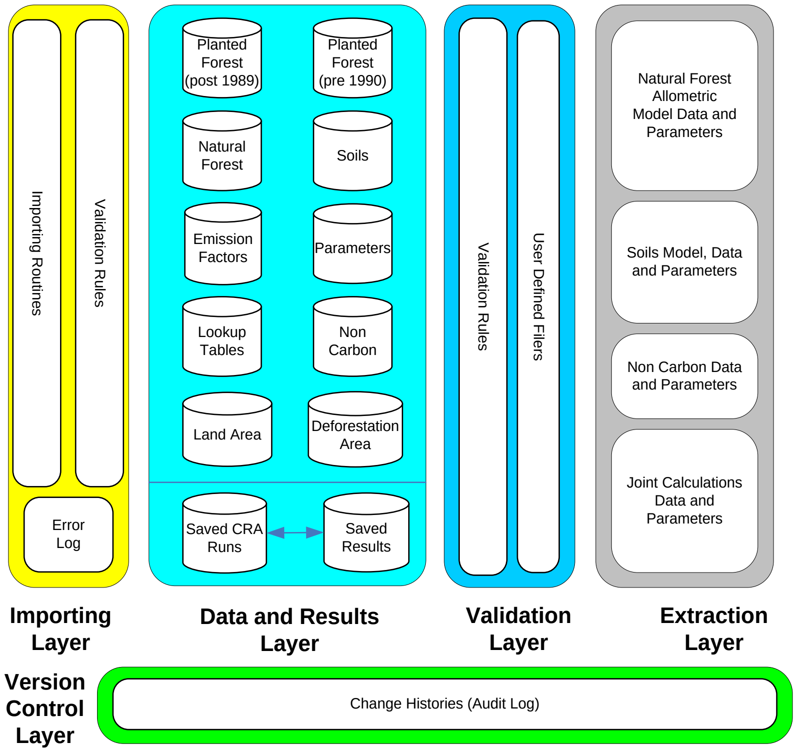
The LUCAS Gateway enables the storage of activity data such as field plot data, land use area, biomass burning and other data needed by the CRA, such as IPCC defaults.

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 (figure A5.2.23). It contains the following main components.

- A data and results layer contains 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 A5.2.23 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 Paris Agreement.

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, 2006b). The results represent carbon stock and change for every 'from' and 'to' land use combination outlined by the IPCC since 1990.

After the user has run 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.

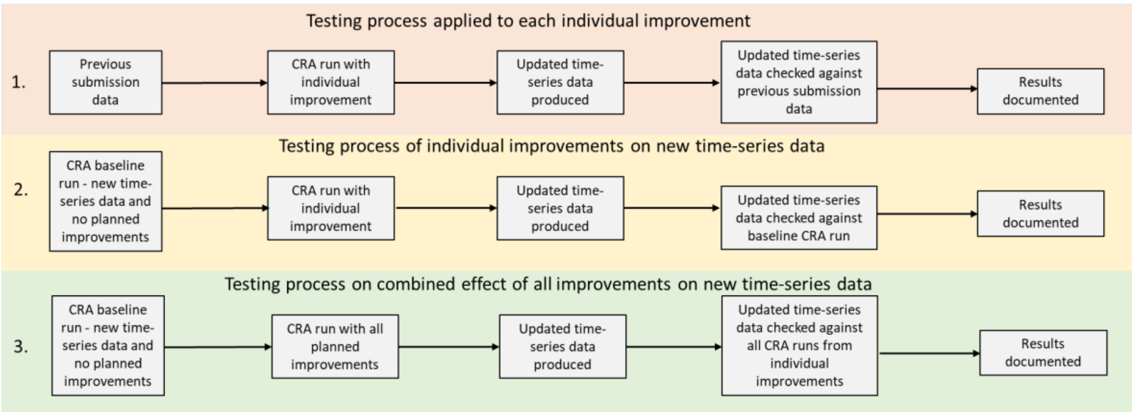
The CRA is maintained and supported by Interpine Innovation, a New Zealand-based company that specialises in forestry inventories and related information technology development. Interpine Innovation also provides support services, such as database and application backups, day-to-day issue resolution 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 A5.2.24.

Figure A5.2.24 Quality-control procedure for implementing improvements



Document management

All reference material, including scientific reports containing information on methodologies or emission factors used in the production of the LULUCF 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.

A5.3 Supplementary information for the Energy sector: 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 A5.3.1 to A5.3.4. Where 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 A5.3.1 Gross carbon dioxide emission factors used for New Zealand's Energy sector for 2022

	Emission factor (t CO_2/TJ)	Source
Gas		
Weighted average	53.99	
Liquid fuels		
Crude oil	69.67	1
Regular petrol	65.91	2
Petrol – premium	65.98	2
Diesel (10 parts (sulphur) per million)	69.17	2
Jet kerosene	68.04	2
Av gas	65.89	2
LPG	59.27	3
Heavy fuel oil	74.54	2
Light fuel oil	73.02	2
Bitumen (asphalt)	76.83	2
Biomass		
Biogas	49.17	1
Wood (industrial)	89.47	1
Bioethanol	64.20	4
Biodiesel	67.26	3
Wood (residential)	85.80	3
Coal		
All sectors excl. electricity (sub-bituminous)	95.47	4
All sectors (bituminous)	87.78	4
All sectors (lignite)	76.12	4

1. IPCC Guidelines (IPCC, 2006a).
2. Refining NZ/fuel importers.
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 A5.3.2 Consumption-weighted average emission factors used for New Zealand's sub-bituminous coal-fired electricity generation for 1990 to 2022

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 A5.3.3 Methane emission factors used for New Zealand's Energy sector for 1990 to 2022

	Emission factor (t CH_4/PJ)	Source
Natural gas		
Electricity industries	0.90	IPCC, 2006a (table 2.2)
Commercial	4.50	IPCC, 2006a (table 2.4)
Residential	4.50	IPCC, 2006a (table 2.5)
Domestic transport (CNG)	82.80	IPCC, 2006a (table 3.2.2)
Other stationary (mainly industrial)	0.90	IPCC, 2006a (table 2.3)
Liquid fuels		
Stationary sources		
Electricity – residual oil	2.85	IPCC, 2006a (table 2.2)
Industrial (including refining) – residual oil	2.85	IPCC, 2006a (table 2.3)
Industrial – LPG	0.95	IPCC, 2006a (table 2.3)
Commercial – residual oil	9.50	IPCC, 2006a (table 2.4)
Commercial – distillate oil	9.50	IPCC, 2006a (table 2.4)
Commercial – LPG	4.75	IPCC, 2006a (table 2.4)
Residential – distillate oil	9.50	IPCC, 2006a (table 2.5)
Residential – LPG	4.75	IPCC, 2006a (table 2.5)
Agriculture – stationary	2.85	IPCC, 2006a (table 2.5)
Mobile sources		
LPG	58.9	IPCC, 2006a (table 3.2.2)
Petrol	28.05	IPCC, 2006a (table 3.2.2)
Diesel	3.71	IPCC, 2006a (table 3.2.2)
Navigation (fuel oil and diesel)	6.65	IPCC, 2006a (table 3.5.3)
Aviation fuel/kerosene	0.48	IPCC, 2006a (table 3.6.5)

	Emission factor (t CH_4/PJ)	Source
Coal		
Electricity generation	0.95	IPCC, 2006a (table 2.2)
Industry	9.50	IPCC, 2006a (table 2.3)
Commercial	9.50	IPCC, 2006a (table 2.4)
Residential	285.00	IPCC, 2006a (table 2.5)
Biomass		
Wood/wood waste	24.00	IPCC, 2006a (table 2.3)
Wood – fireplaces	240.00	IPCC, 2006a (table 2.5) wood – residential
Bioethanol	18.00	IPCC, 2006a (table 3.2.2) – ethanol, cars, Brazil
Biodiesel	18.00	IPCC, 2006a (table 3.2.2) – ethanol, cars, Brazil
Gas biomass	0.90	IPCC, 2006a (table 2.2)

Table A5.3.4 Nitrous oxide emission factors used for New Zealand's Energy sector for 1990 to 2022

	Emission factor (t N_2O/PJ)	Source
Natural gas		
Electricity generation	0.09	IPCC, 2006a (table 2.2)
Commercial	0.09	IPCC, 2006a (table 2.4)
Residential	0.09	IPCC, 2006a (table 2.5)
Domestic transport (CNG)	2.70	IPCC, 2006a (table 3.2.2)
Other stationary (mainly industrial)	0.09	IPCC, 2006a (table 2.3)
Liquid fuels		
Stationary sources		
Electricity – residual oil	0.57	IPCC, 2006a (table 2.2)
Electricity – distillate oil	0.57	IPCC, 2006a (table 2.2)
Industrial (including refining) – residual oil	0.57	IPCC, 2006a (table 2.2)
Industrial – distillate oil	0.57	IPCC, 2006a (table 2.3)
Commercial – residual oil	0.57	IPCC, 2006a (table 2.4)
Commercial – distillate oil	0.57	IPCC, 2006a (table 2.4)
Residential (all oil)	0.57	IPCC, 2006a (table 2.5)
LPG (all uses)	0.095	IPCC, 2006a (tables 2.2–2.5)
Agriculture – stationary	0.38	Tier 2, diesel engines – agriculture
Mobile sources		
LPG	0.19	IPCC, 2006a (table 3.22)
Petrol	7.60	IPCC, 2006a (table 3.2.2)
Diesel	3.71	IPCC, 2006a (table 3.2.2)
Fuel oil (ships)	1.90	IPCC, 2006a (table 3.5.3)
Aviation fuel/kerosene	1.90	IPCC, 2006a (table 3.6.5)
Coal		
Electricity generation	1.43	IPCC, 2006a (table 2.2)
Industry	1.43	IPCC, 2006a (table 2.3)
Commercial	1.43	IPCC, 2006a (table 2.4)
Residential	1.43	IPCC, 2006a (table 2.5)
Biomass		
Wood (all uses)	3.20	IPCC, 2006a (table 2.5) wood/wood waste
Gas biomass	0.09	IPCC, 2006a (table 2.5)

A5.3.1 Emissions from liquid fuels

A5.3.1.1 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, it has no sampling error. The only possible sources of error are non-sampling errors (such as respondent error and processing error). The 2022 statistical difference for liquid fuels in the balance table of the publication *Energy in New Zealand* was 0.7 per cent (MBIE, 2023). This is used as the activity data uncertainty for liquid fuels in 2022.

A5.3.1.2 Emission factors and uncertainties

The CO_2 emission factors are described in table A5.3.1. 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 A5.3.5 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 N_2O emission factors is ±50.0 per cent because almost all emission factors are IPCC defaults.

Table A5.3.6 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 A5.3.5 Carbon content (per cent mass) for liquid fuels for 1990 to 2022

	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
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

	Premium petrol	Regular petrol	Diesel	Jet kerosene	Heavy fuel oil	Light fuel oil	Bitumen (asphalt)
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
2021	85.66	85.53	86.65	86.19	85.97	86.96	86.04
2022	84.94	84.89	86.47	85.99	86.74	86.96	86.56

Table A5.3.6 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)			
	Urban		Rural	Highway	Urban		Rural	Highway
	Cold	Hot			Cold	Hot		
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
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

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	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		
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

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 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

A5.3.2 Emissions from solid fuels

A5.3.2.1 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 2022 statistical difference for solid fuels in the balance table of the publication *Energy in New Zealand* was 15.2 per cent (MBIE, 2023). This is used as the activity data uncertainty for solid fuels in 2022.

A5.3.2.2 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.

A5.3.3 Emissions from gaseous fuels

A5.3.3.1 Activity data

Through the various surveys it conducts 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 2022 statistical difference for gaseous fuels in the balance table of the publication *Energy in New Zealand* was 3.5 per cent (MBIE, 2023). This is used as the activity data uncertainty for gaseous fuels in 2022.

A5.3.3.2 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 2022. The uncertainty for CH_4 and N_2O emission factors is ±50.0 per cent because almost all emission factors are IPCC defaults.

A5.3.4 National 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, 2023), 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 A5.3.7 gives a time series of energy use versus non-energy use of natural gas.

Table A5.3.7 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
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

	Energy use	Non-energy use
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	134.7	45.3
2019	140.7	51.3
2020	136.2	46.6
2021	117.5	38.4
2022	109.2	31.3

Annex 5: References

Some references may be downloaded directly from www.mpi.govt.nz/news-and-resources/statistics-and-forecasting/greenhouse-gas-reporting/agriculture-greenhouse-gas-inventory-reports. The Ministry for Primary Industries is progressively making reports used for the inventory available on this page, provided copyright permits.

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Annex 6: Common reporting tables

The common reporting tables and data for New Zealand are available on the Ministry for the Environment's website: environment.govt.nz/facts-and-science/climate-change/new-zealands-greenhouse-gas-inventory.

Online tools for submitting the common reporting tables to the United Nations Framework Convention on Climate Change (UNFCCC) are under development by the UNFCCC Secretariat at the time of first publishing of this report. It is expected the National Inventory Report, including the national inventory document and common reporting tables, will be submitted to the UNFCCC using the new online tools when they are available. The common reporting tables for New Zealand will then be available on the UN Climate Change website (www.unfccc.int).

Annex 7: Tokelau

A7.1 Emissions estimate data and supporting information by category for Tokelau[9]

Tokelau 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	2000
Fuel Consumption	TJ	3.268	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	3.268
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
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	0.23	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	0.23

[9] The category names and codes for source categories are consistent with New Zealand's emissions data 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. Acronyms are as follows: CH_4 = methane; CO = carbon monoxide; CO_2 = carbon dioxide; D = default emission factor; DC = degradable carbon; dm = dry matter; DOCf = fraction of degradable organic carbon; GCV = gross calorific value; HFCs = hydrofluorocarbons; IE = included elsewhere; MCF = methane correction factor; MJ = megajoule; N = nitrogen; N_2O = nitrous oxide; NA = not applicable; NE = not estimated; NF_3 = nitrogen trifluoride; NMVOC = non-methane volatile organic compound; NO = not occurring; NO_x = nitrogen oxides; PFCs = perfluorocarbons; PJ = petajoule; SF_6 = sulphur hexafluoride; SWDS = solid waste disposable sites; t = tonnes; T1 = Tier 1 method; T1a = Tier 1a method; TJ = terajoule; VS = volatile solids; WWT = wastewater treatment.

[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	2000
CH_4	kt	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093
Liquid fuels	kt	0.0000093	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	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	0.0000019
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 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Fuel Consumption	TJ	3.268	3.268	3.268	9.805	16.342	16.342	16.342	16.342	16.342	16.342	16.342
Liquid fuels	TJ	3.268	3.268	3.268	9.805	16.342	16.342	16.342	16.342	16.342	16.342	16.342
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
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												

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.1 Energy Industries][1.A.1.a Public Electricity and Heat Production]	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
CO_2	kt	0.23	0.23	0.23	0.69	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Liquid fuels	kt	0.23	0.23	0.23	0.69	1.15	1.15	1.15	1.15	1.15	1.15	1.15
CH_4	kt	0.0000093	0.0000093	0.0000093	0.0000279	0.0000466	0.0000466	0.0000466	0.0000466	0.0000466	0.0000466	0.0000466
Liquid fuels	kt	0.0000093	0.0000093	0.0000093	0.0000279	0.0000466	0.0000466	0.0000466	0.0000466	0.0000466	0.0000466	0.0000466
N_2O	kt	0.0000019	0.0000019	0.0000019	0.0000056	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093	0.0000093
Liquid fuels	kt	0.0000019	0.0000019	0.0000019	0.0000056	0.0000093	0.0000093	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	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 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Fuel Consumption	TJ	12.972	2.863	2.863	2.863	3.049	3.235	3.421	3.608	3.206	7.423	18.957
Liquid fuels	TJ	12.972	2.863	2.863	2.863	3.049	3.235	3.421	3.608	3.206	7.423	18.957
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
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

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.1 Energy Industries][1.A.1.a Public Electricity and Heat Production]	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Emissions												
CO_2	kt	0.913	0.202	0.202	0.202	0.215	0.228	0.241	0.254	0.226	0.523	1.334
Liquid fuels	kt	0.913	0.202	0.202	0.202	0.215	0.228	0.241	0.254	0.226	0.523	1.334
CH_4	kt	0.000037	0.0000082	0.0000082	0.0000082	0.0000087	0.0000092	0.0000098	0.0000103	0.0000091	0.0000212	0.000054
Liquid fuels	kt	0.000037	0.0000082	0.0000082	0.0000082	0.0000087	0.0000092	0.0000098	0.0000103	0.0000091	0.0000212	0.000054
N_2O	kt	0.0000074	0.0000016	0.0000016	0.0000016	0.0000017	0.0000018	0.000002	0.0000021	0.0000018	0.0000042	0.0000108
Liquid fuels	kt	0.0000074	0.0000016	0.0000016	0.0000016	0.0000017	0.0000018	0.000002	0.0000021	0.0000018	0.0000042	0.0000108
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 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	2000
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
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

[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	2000
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

Note: This category is included under 1.A.3.d. For explanation, please refer to chapter 8, section 8.2.5.

Tokelau 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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
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 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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
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 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	2000
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

[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	2000
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 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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 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	2000
Fuel consumption	TJ	12.757	12.983	13.209	13.434	13.66	13.886	14.111	14.337	14.563	14.788	15.014
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

[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	2000
Emissions												
CO_2	kt	0.898	0.914	0.93	0.946	0.962	0.977	0.993	1.009	1.025	1.041	1.057
CH_4	kt	0.0000848	0.0000863	0.0000878	0.0000893	0.0000908	0.0000923	0.0000938	0.0000953	0.0000968	0.0000983	0.0000998
N_2O	kt	0.0000242	0.0000247	0.0000251	0.0000255	0.000026	0.0000264	0.0000268	0.0000272	0.0000277	0.0000281	0.0000285
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 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Fuel consumption	TJ	15.24	15.465	15.691	15.917	16.142	16.368	16.594	16.819	17.045	17.271	17.496
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	1.073	1.089	1.105	1.12	1.136	1.152	1.168	1.184	1.2	1.216	1.232
CH_4	kt	0.0001013	0.0001028	0.0001043	0.0001058	0.0001073	0.0001088	0.0001103	0.0001118	0.0001133	0.0001148	0.0001163
N_2O	kt	0.000029	0.0000294	0.0000298	0.0000302	0.0000307	0.0000311	0.0000315	0.000032	0.0000324	0.0000328	0.0000332
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 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Fuel consumption	TJ	17.722	17.947	18.173	18.031	18.886	19.883	21.079	30.915	29.174	19.463	18.561
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	1.248	1.263	1.279	1.269	1.329	1.4	1.484	2.176	2.054	1.37	1.307
CH_4	kt	0.0001179	0.0001194	0.0001209	0.0001199	0.0001256	0.0001322	0.0001402	0.0002056	0.000194	0.0001294	0.0001234
N_2O	kt	0.0000337	0.0000341	0.0000345	0.0000343	0.0000359	0.0000378	0.00004	0.0000587	0.0000554	0.000037	0.0000353
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 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	2000
Fuel Consumption	TJ	2.157	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	IE
Gaseous fuels	TJ	2.157	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	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
CH_4		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	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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	0.123	0.123
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	0.123	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	0.0001204
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	0.0001204	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	0.0000004
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	0.0000004	0.0000004
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												
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 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Fuel Consumption	TJ	2.157	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	IE
Gaseous fuels	TJ	2.157	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	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
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	0.123	0.123
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	0.123	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	0.0001204
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	0.0001204	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	0.0000004
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	0.0000004	0.0000004
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

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.4 Other Sectors][1.A.4.b Residential]	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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												
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 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Fuel Consumption	TJ	2.157	2.157	2.157	2.157	2.157	2.157	2.157	1.252	1.763	1.664	1.711
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	1.252	1.763	1.664	1.711
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
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	0.071	0.1	0.095	0.097
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	0.071	0.1	0.095	0.097

[1. Energy][1.AA Fuel Combustion - Sectoral approach][1.A.4 Other Sectors][1.A.4.b Residential]	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
CH_4	kt	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0001204	0.0000698	0.0000983	0.0000929	0.0000955
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	0.0000698	0.0000983	0.0000929	0.0000955
N_2O	kt	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000002	0.0000003	0.0000003	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	0.0000002	0.0000003	0.0000003	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												
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 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	2000
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
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 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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
CH_4		D	D	D	D	D	D	D	D	D	D	D

[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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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
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 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	2000
Imports	PJ	0.01	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	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	0.01	0.01
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	9.802	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	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	0.176
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	0.176	0.176
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	0.176	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	0.645

Tokelau 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Imports	PJ	0.01	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	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	0.01	0.01
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	9.802	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	17.955

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Gasoline]	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Carbon content												
C	kt	0.176	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	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	0.176
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	0.176	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	0.645

Tokelau 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Imports	PJ	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.009	0.011	0.011	0.009
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	0.009	0.011	0.011	0.009
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	9.387	11.262	10.69	8.687
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	0.169	0.202	0.192	0.156
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	0.169	0.202	0.192	0.156
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	0.169	0.202	0.192	0.156
CO_2	kt	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.618	0.741	0.704	0.572

Tokelau 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	2000
Imports	PJ	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008
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	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008
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	5.834	6.059	6.285	6.511	6.736	6.962	7.188	7.413	7.639	7.865	8.09
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	0.112	0.116	0.121	0.125	0.129	0.134	0.138	0.142	0.147	0.151	0.155
Carbon stored												
C	kt	NO	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	0.155
Fraction of carbon oxidized		1	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	0.155
CO_2	kt	0.41	0.426	0.442	0.458	0.474	0.49	0.506	0.522	0.538	0.553	0.569

Tokelau 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Imports	PJ	0.008	0.009	0.009	0.016	0.022	0.023	0.023	0.023	0.023	0.023	0.024
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	0.008	0.009	0.009	0.016	0.022	0.023	0.023	0.023	0.023	0.023	0.024
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	8.316	8.542	8.767	15.53	22.292	22.518	22.743	22.969	23.195	23.42	23.646
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

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Gas / Diesel Oil]	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Carbon content												
C	kt	0.16	0.164	0.168	0.298	0.428	0.432	0.436	0.441	0.445	0.449	0.454
Carbon stored												
C	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Net carbon emissions												
C	kt	0.16	0.164	0.168	0.298	0.428	0.432	0.436	0.441	0.445	0.449	0.454
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1	1
Emissions												
C	kt	0.16	0.164	0.168	0.298	0.428	0.432	0.436	0.441	0.445	0.449	0.454
CO_2	kt	0.585	0.601	0.617	1.093	1.569	1.584	1.6	1.616	1.632	1.648	1.664

Tokelau 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Imports	PJ	0.021	0.011	0.011	0.011	0.012	0.013	0.014	0.025	0.021	0.016	0.029
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	0.021	0.011	0.011	0.011	0.012	0.013	0.014	0.025	0.021	0.016	0.029
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	20.502	10.618	10.844	10.701	11.743	12.927	14.308	24.984	20.916	16.095	28.527
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	0.393	0.204	0.208	0.205	0.225	0.248	0.275	0.479	0.401	0.309	0.547
Carbon stored												
C	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Net carbon emissions												
C	kt	0.393	0.204	0.208	0.205	0.225	0.248	0.275	0.479	0.401	0.309	0.547
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1	1
Emissions												
C	kt	0.393	0.204	0.208	0.205	0.225	0.248	0.275	0.479	0.401	0.309	0.547
CO_2	kt	1.443	0.747	0.763	0.753	0.826	0.91	1.007	1.758	1.472	1.133	2.007

Tokelau 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	2000
Imports	PJ	0.0006661	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	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	0.0006661	0.0006661
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	0.666	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	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	0.012
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	0.012	0.012
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	0.012	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	0.045

Tokelau 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Imports	PJ	0.0006661	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	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	0.0006661	0.0006661
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][Other Kerosene]	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Apparent consumption	TJ	0.666	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	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	0.012
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	0.012	0.012
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	0.012	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	0.045

Tokelau 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Imports	PJ	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0006661	0.0002342	0.0000952	0.000205	0.0007686
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	0.0002342	0.0000952	0.000205	0.0007686
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	0.234	0.095	0.205	0.769
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	0.004	0.002	0.004	0.014
Carbon stored												
C	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Other Kerosene]	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Net carbon emissions												
C	kt	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.004	0.002	0.004	0.014
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	0.004	0.002	0.004	0.014
CO_2	kt	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.016	0.006	0.014	0.052

Tokelau 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	2000
Imports	PJ	0.001	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	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	0.001
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	1.491	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	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	0.023
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	0.023	0.023
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	0.023	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	0.085

Tokelau 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Imports	PJ	0.001	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	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	0.001
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	1.491	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	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	0.023
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	0.023	0.023
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	0.023	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	0.085

Tokelau 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Imports	PJ	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.0009428
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	0.002	0.001	0.0009428
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	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.017	1.667	1.459	0.943

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Liquefied Petroleum Gases (LPG)]	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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	0.016	0.026	0.023	0.015
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	0.016	0.026	0.023	0.015
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	0.016	0.026	0.023	0.015
CO_2	kt	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.058	0.095	0.083	0.054

Tokelau 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	2000
Imports	PJ	0.0003901	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	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	0.0003901	0.0003901
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	0.39	0.39
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	0.007	0.007
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	0.007	0.007
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1	1

[1. Energy][1.AB Fuel Combustion - Reference Approach][Liquid Fuels][Lubricants]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Emissions												
C	kt	0.008	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	0.029

Tokelau 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Imports	PJ	0.0003901	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	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	0.0003901	0.0003901
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	0.39	0.39
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	0.007	0.007
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	0.007	0.007
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	0.008	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	0.029

Tokelau 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Imports	PJ	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0003901	0.0001519	0.0002028	0.0001007	0.0003035
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	0.0001519	0.0002028	0.0001007	0.0003035
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	0.152	0.203	0.101	0.303
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	0.003	0.004	0.002	0.006
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	0.003	0.004	0.002	0.006
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	0.003	0.004	0.002	0.006
CO_2	kt	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.011	0.015	0.007	0.022

Tokelau 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	2000
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	NO	NO	NO	0.016	0.039	0.067	0.088	0.107	0.126	0.143
Remaining in products at decommissioning	t	NO	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	0.022
From manufacturing	t	NO	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	0.022

[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	2000
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	%	NO	NO	NO	NO	15	15	15	15	15	15	15
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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	0.16	0.201	0.247	0.271	0.295	0.318	0.316	0.313	0.311	0.308	0.306
Remaining in products at decommissioning	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	0.024	0.03	0.037	0.041	0.044	0.048	0.047	0.047	0.047	0.046	0.046
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	0.024	0.03	0.037	0.041	0.044	0.048	0.047	0.047	0.047	0.046	0.046
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 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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	0.286	0.267	0.247	0.228	0.208	0.208	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

[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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Emissions	t	0.043	0.04	0.037	0.034	0.031	0.031	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	0.043	0.04	0.037	0.034	0.031	0.031	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 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	2000
Method												
HFCs		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
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		NA	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	NO
HFC-32	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-125	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-134a	t	NO	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	NO
Recovery												
Aggregate F-gases	t CO_2-e	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Method												
HFCs		NA	NA	NA	NA	NA	NA	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		NA	NA	NA	NA	NA	NA	D	D	D	D	D
Emissions												
HFCs	t CO_2-e	NO	NO	NO	NO	NO	NO	15.651	31.302	46.953	62.603	78.254
HFC-32	t	NO	NO	NO	NO	NO	NO	0.003	0.006	0.009	0.012	0.015
HFC-125	t	NO	NO	NO	NO	NO	NO	0.004	0.008	0.013	0.017	0.021
HFC-134a	t	NO	NO	NO	NO	NO	NO	0.000285	0.00057	0.000855	0.001	0.001
HFCs and PFCs	t CO_2-e	NO	NO	NO	NO	NO	NO	15.651	31.302	46.953	62.603	78.254
Recovery												
Aggregate F-gases	t CO_2-e	NO	NO	NO	NO	NO	NO	15.651	31.302	46.953	62.603	78.254

Tokelau 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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	93.905	109.556	125.207	140.858	156.509	156.509	156.509	156.509	156.509	156.509	156.509

[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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
HFC-32	t	0.018	0.021	0.024	0.027	0.03	0.03	0.03	0.03	0.03	0.03	0.03
HFC-125	t	0.025	0.029	0.033	0.038	0.042	0.042	0.042	0.042	0.042	0.042	0.042
HFC-134a	t	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
HFCs and PFCs	t CO_2-e	93.905	109.556	125.207	140.858	156.509	156.509	156.509	156.509	156.509	156.509	156.509
Recovery												
Aggregate F-gases	t CO_2-e	93.905	109.556	125.207	140.858	156.509	156.509	156.509	156.509	156.509	156.509	156.509

Tokelau 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	2000
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	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	NO
Emissions	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
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	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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	NO	NO	NO	NO	NO	0.02	0.041	0.061	0.081	0.102
Remaining in products at decommissioning	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	NO	NO	NO	NO	NO	NO	0.003	0.006	0.009	0.012	0.015
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	NO	NO	NO	NO	NO	NO	0.003	0.006	0.009	0.012	0.015
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	%	NO	NO	NO	NO	NO	NO	15	15	15	15	15
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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	0.122	0.142	0.162	0.183	0.203	0.203	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	0.018	0.021	0.024	0.027	0.03	0.03	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	0.018	0.021	0.024	0.027	0.03	0.03	0.03	0.03	0.03	0.03	0.03
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 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	2000
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	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	NO
Emissions	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
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	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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	NO	NO	NO	NO	NO	0.028	0.056	0.083	0.111	0.139
Remaining in products at decommissioning	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	NO	NO	NO	NO	NO	NO	0.004	0.008	0.013	0.017	0.021
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	NO	NO	NO	NO	NO	NO	0.004	0.008	0.013	0.017	0.021
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	%	NO	NO	NO	NO	NO	NO	15	15	15	15	15
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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	0.167	0.195	0.222	0.25	0.278	0.278	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	0.025	0.029	0.033	0.038	0.042	0.042	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	0.025	0.029	0.033	0.038	0.042	0.042	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
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 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	2000
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	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	NO
Emissions	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
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	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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	NO	NO	NO	NO	NO	0.002	0.004	0.006	0.008	0.01
Remaining in products at decommissioning	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	NO	NO	NO	NO	NO	NO	0.000285	0.00057	0.000855	0.001	0.001
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	NO	NO	NO	NO	NO	NO	0.000285	0.00057	0.000855	0.001	0.001
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	%	NO	NO	NO	NO	NO	NO	15	15	15	15	15
Disposal loss factor	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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	0.013	0.015	0.017	0.019	0.019	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	0.002	0.002	0.002	0.003	0.003	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	0.002	0.002	0.002	0.003	0.003	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
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 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	2000
Method												
HFCs		NA	NA	NA	NA	NA	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		NA	NA	NA	NA	NA	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	NO	NO	NO	NO	NO	0.000108	0.0006358	0.001	0.002	0.002	0.003
HFCs	t CO_2-equivalent	NO	NO	NO	NO	NO	0.108	0.636	1.04	1.538	2.218	2.594
HFC-134a	t	NO	NO	NO	NO	NO	0.0000831	0.0004891	0.0008003	0.001	0.002	0.002
HFC-227ea	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Aggregate F-gases	t CO_2-equivalent	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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
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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
NF_3		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emissions	kt CO_2-equivalent	0.006	0.01	0.013	0.012	0.012	0.012	0.012	0.013	0.013	0.014	0.016
HFCs	t CO_2-equivalent	5.538	10.49	12.636	12.414	12.418	12.137	12.38	12.887	13.42	14.053	15.8
HFC-134a	t	0.004	0.008	0.01	0.01	0.01	0.009	0.01	0.01	0.01	0.011	0.011
HFC-227ea	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.0003553
Aggregate F-gases	t CO_2-equivalent	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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
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	0.018	0.018	0.018	0.018	0.018	0.017	0.017	0.016	0.015	0.014	0.014
HFCs	t CO_2-equivalent	17.512	17.663	17.669	17.945	17.86	17.414	16.865	16.374	15.085	13.755	13.755
HFC-134a	t	0.012	0.012	0.012	0.012	0.012	0.012	0.011	0.011	0.01	0.009	0.009
HFC-227ea	t	0.0007195	0.0007207	0.0007209	0.0007322	0.0007197	0.0006808	0.0006386	0.0006042	0.0005371	0.0004756	0.0004756
Aggregate F-gases	t CO_2-equivalent	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau 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	2000
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	NO	NO	NO	NO	0.0000831	0.0004891	0.0008003	0.001	0.002	0.002
Emissions	t	NO	NO	NO	NO	NO	0.0000831	0.0004891	0.0008003	0.001	0.002	0.002
From manufacturing	t	NO	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	0.002
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	NO	NO	NO	NO	100	100	100	100	100	100

Tokelau 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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	0.004	0.008	0.01	0.01	0.01	0.009	0.01	0.01	0.01	0.011	0.011
Emissions	t	0.004	0.008	0.01	0.01	0.01	0.009	0.01	0.01	0.01	0.011	0.011
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	0.004	0.008	0.01	0.01	0.01	0.009	0.01	0.01	0.01	0.011	0.011
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 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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	0.012	0.012	0.012	0.012	0.012	0.012	0.011	0.011	0.01	0.009	0.009
Emissions	t	0.012	0.012	0.012	0.012	0.012	0.012	0.011	0.011	0.01	0.009	0.009
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	0.012	0.012	0.012	0.012	0.012	0.012	0.011	0.011	0.01	0.009	0.009
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 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	2000
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	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	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	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.0003553
Emissions	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.0003553
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.0003553
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	NO	NO	NO	NO	NO	NO	NO	NO	NO	100

Tokelau 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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	0.0007195	0.0007207	0.0007209	0.0007322	0.0007197	0.0006808	0.0006386	0.0006042	0.0005371	0.0004756	0.0004756
Emissions	t	0.0007195	0.0007207	0.0007209	0.0007322	0.0007197	0.0006808	0.0006386	0.0006042	0.0005371	0.0004756	0.0004756
From manufacturing	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
From stocks	t	0.0007195	0.0007207	0.0007209	0.0007322	0.0007197	0.0006808	0.0006386	0.0006042	0.0005371	0.0004756	0.0004756
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 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 N_2O from Product Uses][2.G.3.a Medical Applications]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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	0.0000756
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	0.000158	0.0001428	0.0001337	0.0001249	0.0001166	0.0001086	0.0001012	0.0000944	0.0000884	0.0000828	0.0000776
Recovery												
N_2O	kt	NO	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	1.026

Tokelau 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 N_2O from Product Uses][2.G.3.a Medical Applications]	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Activity data												
N_2O	kt	0.0000705	0.000063	0.0000553	0.0000482	0.0000416	0.0000355	0.0000453	0.0000514	0.000046	0.0000519	0.0000459
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	0.0000724	0.0000647	0.0000573	0.0000502	0.0000435	0.0000373	0.0000405	0.0000484	0.0000486	0.0000489	0.000049
Recovery												
N_2O	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor												
N_2O	t/t	1.026	1.026	1.036	1.042	1.045	1.05	0.892	0.941	1.057	0.943	1.067

Tokelau 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 N_2O from Product Uses][2.G.3.a Medical Applications]	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Activity data												
N_2O	kt	0.0000538	0.000054	0.0000536	0.0000564	0.0000506	0.0000597	0.0000838	0.0000596	0.000067	0.0000852	0.0000852
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	0.00005	0.0000539	0.0000536	0.0000547	0.0000532	0.0000547	0.0000713	0.0000711	0.0000629	0.000076	0.000076
Recovery												
N_2O	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor												
N_2O	t/t	0.93	0.999	1.001	0.971	1.052	0.916	0.851	1.193	0.939	0.892	0.892

Tokelau 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	2000
Population	1000s	2.293	2.5	2.395	2.29	2.186	2.081	1.976	2.111	2.247	2.382	2.518
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		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	0.003	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	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	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

[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	2000
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 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Population	1000s	2.653	2.633	2.613	2.592	2.572	2.552	2.514	2.476	2.438	2.4	2.362
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		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	0.004	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	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 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Population	1000s	2.219	2.076	1.933	1.79	1.647	1.647	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
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	0.003	0.003	0.003	0.003	0.002	0.002	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 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	2000
Population	1000s	3.439	3.5	3.394	3.288	3.182	3.076	2.97	2.84	2.709	2.579	2.448
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

[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	2000
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 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Population	1000s	2.318	2.229	2.14	2.052	1.963	1.874	1.712	1.55	1.388	1.226	1.064
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 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Population	1000s	0.976	0.888	0.801	0.713	0.625	0.625	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 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	2000
Population	1000s	2.293	2.5	2.395	2.29	2.186	2.081	1.976	2.111	2.247	2.382	2.518
Allocation by climate region												
Warm	%	100	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	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

[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	2000
Emission factor information												
CH_4		D	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	0.047
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 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Population	1000s	2.653	2.633	2.613	2.592	2.572	2.552	2.514	2.476	2.438	2.4	2.362
Allocation by climate region												
Warm	%	100	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	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	0.049	0.049	0.048	0.048	0.048	0.047	0.047	0.046	0.045	0.044	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	18.5

Tokelau 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Population	1000s	2.219	2.076	1.933	1.79	1.647	1.647	1.647	1.647	1.647	1.647	1.647
Allocation by climate region												
Warm	%	100	100	100	100	100	100	101	102	103	104	105
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

[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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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	0.041	0.038	0.036	0.033	0.03	0.03	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 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	2000
Population	1000s	3.439	3.5	3.394	3.288	3.182	3.076	2.97	2.84	2.709	2.579	2.448
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
Emission factor information												
CH_4		D	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	0.0000735
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 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Population	1000s	2.318	2.229	2.14	2.052	1.963	1.874	1.712	1.55	1.388	1.226	1.064
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
Emission factor information												
CH_4		D	D	D	D	D	D	D	D	D	D	D
Emissions												
CH_4	kt	0.0000695	0.0000669	0.0000642	0.0000615	0.0000589	0.0000562	0.0000514	0.0000465	0.0000416	0.0000368	0.0000319
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 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Population	1000s	0.976	0.888	0.801	0.713	0.625	0.625	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

[Sectors/Totals][3. Agriculture] [3.1 Livestock][3.B Manure Management][3.B.1 CH4 Emissions][3.B.1.4 Other livestock][Poultry]	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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	0.0000293	0.0000267	0.000024	0.0000214	0.0000187	0.0000187	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 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	2000
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	0.441	0.438	0.435	0.431	0.429	0.426	0.423	0.421	0.418	0.416	0.413
CO_2	kt	NA	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	0.015
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 Table 5.A: [5. Waste][5.A Solid Waste Disposal] (Part 2 of 3)

[5. Waste][5.A Solid Waste Disposal]	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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	0.41	0.407	0.402	0.396	0.388	0.378	0.368	0.359	0.353	0.348	0.344
CO_2	kt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4	kt	0.015	0.015	0.014	0.014	0.014	0.014	0.013	0.013	0.013	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 Table 5.A: [5. Waste][5.A Solid Waste Disposal] (Part 3 of 3)

[5. Waste][5.A Solid Waste Disposal]	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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	0.341	0.339	0.339	0.339	0.339	0.341	0.342	0.343	0.344	0.345	0.346
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 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	2000
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	0.504
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	0.016	0.016	0.016	0.015	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	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	0.029	0.03	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029

Tokelau 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Annual waste at the SWDS	kt	0.5	0.479	0.459	0.438	0.418	0.397	0.401	0.405	0.408	0.412	0.416
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

[5. Waste][5.A Solid Waste Disposal][5.A.3 Uncategorized Waste Disposal Sites]	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Emissions												
CO_2	kt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4												
Emissions	kt	0.015	0.015	0.014	0.014	0.014	0.014	0.013	0.013	0.013	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	0.029	0.03	0.031	0.032	0.033	0.034	0.033	0.032	0.031	0.03	0.03

Tokelau 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Annual waste at the SWDS	kt	0.421	0.427	0.432	0.438	0.443	0.444	0.445	0.447	0.447	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

[5. Waste][5.A Solid Waste Disposal][5.A.3 Uncategorized Waste Disposal Sites]	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Implied emission factor												
CO_2	t/t	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH_4	t/t	0.029	0.028	0.028	0.028	0.027	0.027	0.027	0.027	0.028	0.028	0.028

Tokelau 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	2000
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	0.504
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	0.047	0.046	0.046	0.046	0.045	0.045	0.045	0.045	0.044	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	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	0.0000424
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 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Amount of wastes incinerated/open burned	kt	0.5	0.479	0.459	0.438	0.418	0.397	0.401	0.405	0.408	0.412	0.416
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	0.043	0.042	0.04	0.038	0.036	0.034	0.035	0.035	0.035	0.036	0.036
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	0.0000421	0.0000404	0.0000386	0.0000369	0.0000352	0.0000334	0.0000337	0.0000341	0.0000344	0.0000347	0.000035
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 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Amount of wastes incinerated/open burned	kt	0.421	0.427	0.432	0.438	0.443	0.444	0.445	0.447	0.447	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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Emissions												
CO_2	kt	0.037	0.037	0.037	0.038	0.038	0.039	0.039	0.039	0.039	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	0.0000355	0.0000359	0.0000364	0.0000369	0.0000373	0.0000374	0.0000374	0.0000376	0.0000376	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 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	2000
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	0.182	0.184	0.19	0.197	0.203	0.209	0.215	0.23	0.244	0.258	0.271
CH_4	kt	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.009	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	0.0000214
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
Additional information												
Population	1000s	1.568	1.537	1.531	1.525	1.519	1.513	1.507	1.495	1.484	1.472	1.461
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

[5. Waste][5.D Wastewater Treatment and Discharge]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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	0	0	0

Tokelau Table 5.D: [5. Waste][5.D Wastewater Treatment and Discharge] (Part 2 of 3)

[5. Waste][5.D Wastewater Treatment and Discharge]	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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	0.285	0.276	0.266	0.257	0.247	0.237	0.241	0.245	0.25	0.254	0.258
CH_4	kt	0.01	0.01	0.009	0.009	0.009	0.008	0.009	0.009	0.009	0.009	0.009
N_2O	kt	0.000016	0.0000145	0.0000131	0.0000117	0.0000104	0.0000092	0.0000087	0.0000081	0.0000075	0.0000069	0.0000063
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
Additional information												
Population	1000s	1.449	1.389	1.33	1.27	1.211	1.151	1.162	1.173	1.183	1.194	1.205
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	0	0	0

Tokelau Table 5.D: [5. Waste][5.D Wastewater Treatment and Discharge] (Part 3 of 3)

[5. Waste][5.D Wastewater Treatment and Discharge]	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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	0.265	0.273	0.28	0.288	0.295	0.296	0.296	0.298	0.298	0.298	0.298
CH_4	kt	0.009	0.01	0.01	0.01	0.011	0.011	0.011	0.011	0.011	0.011	0.011
N_2O	kt	0.0000051	0.0000039	0.0000026	0.0000013	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
Additional information												
Population	1000s	1.221	1.237	1.253	1.269	1.285	1.287	1.289	1.295	1.295	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	1	2	3	4	5

Tokelau 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	2000
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	0.04
Sludge removed	kt DC	NO	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	0.003
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

[5. Waste][5.D Wastewater Treatment and Discharge][5.D.1 Domestic Wastewater]	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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	0.009
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	0.0000593	0.0000562	0.0000537	0.0000511	0.0000486	0.0000461	0.0000436	0.0000379	0.0000323	0.0000268	0.0000214
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	0.138	0.144	0.15	0.157	0.163	0.17	0.176	0.191	0.207	0.222	0.237
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	0.005

Tokelau 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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total organic product	kt DC	0.04	0.038	0.036	0.035	0.033	0.032	0.032	0.032	0.032	0.033	0.033
Sludge removed	kt DC	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
N in effluent	kt	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.0009546	0.0008781	0.0008
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	0.01	0.01	0.009	0.009	0.009	0.008	0.009	0.009	0.009	0.009	0.009
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	0.000016	0.0000145	0.0000131	0.0000117	0.0000104	0.0000092	0.0000087	0.0000081	0.0000075	0.0000069	0.0000063

[5. Waste][5.D Wastewater Treatment and Discharge][5.D.1 Domestic Wastewater]	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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	0.253	0.255	0.258	0.26	0.263	0.266	0.268	0.27	0.273	0.275	0.278
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	0.005

Tokelau 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	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Total organic product	kt DC	0.033	0.034	0.034	0.035	0.035	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	0.0006485	0.0004927	0.0003327	0.0001685	NO	NO	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	0.01	0.01	0.01	0.011	0.011	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	0.0000051	0.0000039	0.0000026	0.0000013	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												
CH_4	kg/kg DC	0.282	0.287	0.291	0.296	0.3	0.3	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	NO	NO	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 growth.

New Zealand's farmers use both organic and synthetic nitrogen fertilisers. The main type of synthetic nitrogen fertiliser used in New Zealand is urea, followed by smaller amounts of diammonium phosphate (DAP) and ammonium sulphate. Urea is mainly applied to dairy pastures to boost pasture growth during the autumn and spring months.

All nitrogen fertilisers provide nitrogen 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).

Currently the Agriculture inventory model assumes emissions from organic fertilisers come solely from animal manure. Most animal manure in New Zealand is excreted directly onto pasture, but some manure 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) nitrogen 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 nitrogen fertilisers and are reported under a dedicated category 3.H.

2022

In 2022, the combined effect of synthetic and organic nitrogen fertilisers totalled 32.2 per cent of emissions from the *Agricultural soils* category and 6.2 per cent of total 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 2022

Fertiliser type	Gas and source	Emissions kt CO_2-e	Percentage of: N_2O emissions from Agriculture soils by gas (%)	Percentage of: All emissions from Agriculture (%)
Synthetic nitrogen fertiliser	Direct N_2O emissions	961.4	15.2	2.3
	Urea N_2O	624.1	9.9	1.5
	Other synthetic nitrogen fertilisers	337.3	5.3	0.8
	Indirect N_2O emissions from all synthetic nitrogen fertilisers	199.1	3.1	0.5
	All N_2O (direct + indirect) from synthetic nitrogen fertilisers	1,160.4	18.4	2.8
	CO_2 from urea	404.9	NA	1.0
Organic fertiliser	Direct N_2O emissions	65.0	1.0	0.2
	Indirect N_2O emissions	27.0	0.4	0.1
	All N_2O (direct + indirect) from organic fertilisers	92.0	1.5	0.2

Note: NA = not applicable. Columns may not add up due to rounding.

1990–2022

The total amount of fertilisers applied to agricultural soils in New Zealand has significantly increased since 1990. Since 1990, synthetic nitrogen fertiliser applied to agricultural land has increased by 465.3 per cent, while organic fertiliser use has grown by 161.2 per cent (table A8.1.2).

Table A8.1.2 Use of fertilisers in New Zealand in 1990 and 2022

Fertiliser type	1990 Application tonnes (N)	1990 Percentage of synthetic nitrogen fertiliser (%)	1990 Percentage of all fertilisers (%)	2022 Application tonnes (N)	2022 Percentage of synthetic nitrogen fertiliser (%)	2022 Percentage of all fertilisers (%)	Change in the use between 1990 and 2022 tonnes (N)	Change in the use between 1990 and 2022 (%)
Synthetic nitrogen fertiliser (ammonium phosphates, for example, DAP)	34,679	58.5	46.4	81,000	24.2	19.4	46,321	133.6
Urea	24,586	41.5	32.9	254,000	75.8	71.7	229,414	933.1
Total synthetic nitrogen fertilisers (urea + ammonium phosphates)	59,265	100.0	79.2	335,000	100.0	89.2	275,735	465.3
Organic fertilisers (animal manure applied to soils)	15,544	NA	20.8	40,594	NA	10.8	25,050	161.2

Note: DAP = diammonium phosphate; NA = not applicable. Columns may not add up due to rounding.

Between 1990 and 2022, N_2O emissions from synthetic nitrogen fertiliser (both direct and indirect emissions, including urea) have increased by 374.3 per cent, while total emissions from these fertilisers (N_2O and CO_2) have increased by 451.4 per cent. For the same period, total emissions from organic fertilisers increased by 116.6 per cent (see table A8.1.3).

In 1990 and 2022 respectively, 0.7 per cent and 2.8 per cent of total agricultural emissions originated from N_2O from synthetic nitrogen fertiliser. Total emissions from synthetic nitrogen fertiliser (including CO_2 from urea) have increased from 0.8 per cent to 3.8 per cent of total agricultural emissions for 1990 and 2022 respectively (see chapter 5, for further details).

Table A8.1.3 Emissions from fertilisers in 1990 and 2022

			Synthetic nitrogen fertilisers	Organic fertilisers
1990	N_2O emissions	kt CO_2-e	244.7	42.5
	CO_2 emissions	kt	39.2	NA
	Total emissions	**kt CO_2-e**	**283.9**	**42.5**
2022	N_2O emissions	kt CO_2-e	1,160.4	92.1
	CO_2 emissions	kt	404.9	NA
	Total emissions	**kt CO_2-e**	**1,565.4**	**92.1**
Change in N_2O emissions between 1990 and 2022		kt CO_2-e	915.8	49.6
Percentage change in N_2O emissions between 1990 and 2022		%	374.3	116.7
Change in all emissions between 1990 and 2022		kt CO_2-e	1,281.5	49.6
Percentage change in all emissions between 1990 and 2022		%	451.4	116.7

Note: NA = not applicable.

A8.2 Agricultural emissions by livestock type

This section covers the distribution of all greenhouse gas emissions from the Agriculture sector by livestock type in 1990, 2021 and 2022, 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 tables (sector 3 – Agriculture).

Table A8.2.1 Total emissions by livestock type in 1990, 2021 and 2022

	1990	2021	2022	1990–2022		2021–2022	
Livestock type			kt CO_2-e	kt CO_2-e	(%)	kt CO_2-e	(%)
Dairy cattle	8,732.4	19,930.8	20,127.6	11,395.1	130.5	196.8	1.0
Beef cattle	8,421.0	8,485.9	8,251.5	-169.6	-2.0	-234.4	-2.8
Sheep	17,572.2	9,834.8	9,716.4	-7,855.9	-44.7	-118.4	-1.2
Deer	543.4	592.7	570.6	27.3	5.0	-22.1	-3.7
Swine	106.7	72.0	70.7	-36.0	-33.8	-1.4	-1.9
Goats	280.6	37.1	28.1	-252.5	-90.0	-9.0	-24.2
Horses	80.9	34.7	28.9	-52.0	-64.3	-5.8	-16.7
Alpaca	0.1	2.2	2.1	2.0	1,735.8	-0.1	-3.8
Mules and asses	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Poultry (including all types of poultry)	24.8	57.5	54.3	29.5	118.8	-3.2	-5.5
Total, all livestock types	**35,762.3**	**39,047.7**	**38,850.2**	**3,087.9**	**8.6**	**-197.5**	**-0.5**

Note: Columns may not add up due to rounding.