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New Zealand's Greenhouse Gas Inventory

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

Te Rārangi Haurehu Kati Mahana a Aotearoa



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 following Approach 1 level and trend methodologies from the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC, 2006). The methodologies applied were determined using the decision tree shown in figure 4.2 of volume 1 of the 2006 IPCC Guidelines (IPCC, 2006). Approach 1 level and trend methodologies were used because some categories in the Inventory apply default uncertainties values for emission estimates.

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 that 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 Enhanced Transparency Framework (ETF) Greenhouse Gas (GHG) Inventory Reporting Tool 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 ETF GHG Inventory Reporting Tool. 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 2023 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 2023 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 emissions and removals and gross emissions in 2023 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 2023

CRT category code	IPCC category	Gas	2023 estimate (kt CO ₂ -e)	Level assessment (%)	Cumulative total (%)
4.A.1.	Carbon stock change – Forest land remaining forest land	CO ₂	-16,012.6	15.3	15.3
3.A.1.a.	Option A – Dairy cattle	CH ₄	15,590.4	14.9	30.1
1.A.3.b.	Transport – Road transportation	CO ₂	12,510.8	11.9	42.1
3.A.2.	Enteric fermentation – Sheep	CH ₄	8,493.7	8.1	50.2
3.A.1.b.	Option A – Non-dairy cattle	CH ₄	7,125.9	6.8	57.0
4.G.	Land use, land-use change and forestry – Harvested wood products	CO ₂	-5,808.3	5.5	62.5
3.D.1.c.	Direct N ₂ O emissions from managed soils – Urine and dung deposited by grazing animals	N ₂ O	3,151.8	3.0	65.5
4.A.2.	Carbon stock change – Land converted to forest land	CO ₂	-2,475.7	2.4	67.9
5.A.	Waste – Solid waste disposal	CH ₄	2,256.8	2.2	70.0
1.A.1.a.	Energy industries – Public electricity and heat production	CO ₂	2,201.4	2.1	72.1
4.C.2.	Carbon stock change – Land converted to grassland	CO ₂	1,543.4	1.5	73.6
3.B.1.a.	Option A – Dairy cattle	CH ₄	1,519.0	1.4	75.1
2.C.1.	Metal industry – Iron and steel production	CO ₂	1,496.4	1.4	76.5
1.A.4.b.	Other sectors – Residential	CO ₂	1,339.2	1.3	77.8
4.C.1.	Carbon stock change – Grassland remaining grassland	CO ₂	1,310.7	1.3	79.0
1.A.2.c.	Chemicals – Gaseous fuels	CO ₂	1,305.9	1.2	80.3
1.A.2.e.	Food processing, beverages and tobacco – Solid fuels	CO ₂	1,257.8	1.2	81.5
1.A.3.a.	Domestic aviation – Jet kerosene	CO ₂	1,235.2	1.2	82.6
1.A.4.c.	Other sectors – Agriculture/forestry/fishing	CO ₂	1,176.5	1.1	83.8
1.A.2.e.	Food processing, beverages and tobacco – Gaseous fuels	CO ₂	1,116.7	1.1	84.8
3.D.1.a.	Direct N ₂ O emissions from managed soils – Inorganic N fertilizers	N ₂ O	1,109.9	1.1	85.9
2.F.1.	Product uses as substitutes for ODS – Refrigeration and air-conditioning	HFCs	1,011.4	1.0	86.8
3.D.2.a.	Indirect N ₂ O emissions from managed soils – Atmospheric deposition	N ₂ O	741.1	0.7	87.6
1.A.4.a.	Other sectors – Commercial/institutional	CO ₂	725.7	0.7	88.2
3.D.1.f.	Direct N ₂ O emissions from managed soils – Cultivation of organic soils	N ₂ O	590.0	0.6	88.8
2.C.3.	Metal industry – Aluminium production	CO ₂	543.0	0.5	89.3
1.A.1.a.	Energy industries – Public electricity and heat production	CO ₂	527.4	0.5	89.8
1.A.2.g.v.	Construction – Liquid fuels	CO ₂	519.1	0.5	90.3
3.D.2.b.	Indirect N ₂ O emissions from managed soils – Nitrogen leaching and run-off	N ₂ O	476.1	0.5	90.8
4.B.2.	Carbon stock change – Land converted to cropland	CO ₂	466.4	0.4	91.2
3.H.	Agriculture – Urea application	CO ₂	425.7	0.4	91.6
1.A.4.a.	Other sectors – Commercial/institutional	CO ₂	419.1	0.4	92.0
3.A.4.c.	Other livestock – Deer	CH ₄	406.2	0.4	92.4

CRT category code	IPCC category	Gas	2023 estimate (kt CO ₂ -e)	Level assessment (%)	Cumulative total (%)
1.A.4.b.	Other sectors – Residential	CO ₂	389.5	0.4	92.8
2.A.1.	Mineral industry – Cement production	CO ₂	379.0	0.4	93.1
1.B.2.d.	Other (please specify) – Geothermal	CO ₂	376.1	0.4	93.5
1.B.2.c.i.2.	Venting – Gas	CO ₂	350.8	0.3	93.8
1.A.2.g.iii.	Mining (excluding fuels) and quarrying – Liquid fuels	CO ₂	323.8	0.3	94.1
1.A.2.e.	Food processing, beverages and tobacco – Liquid fuels	CO ₂	317.5	0.3	94.5
5.D.	Waste – Wastewater treatment and discharge	CH ₄	290.7	0.3	94.7
3.G.	Agriculture – Liming	CO ₂	273.8	0.3	95.0
4.B.1.	Carbon stock change – Cropland remaining cropland	CO ₂	256.1	0.2	95.2
1.A.2.d.	Pulp, paper and print – Gaseous fuels	CO ₂	240.0	0.2	95.5
3.D.1.d.	Direct N ₂ O emissions from managed soils – Crop residues	N ₂ O	230.0	0.2	95.7
1.A.2.g.viii.	Other – Other (please specify)	CO ₂	224.1	0.2	95.9
1.A.2.f.	Non-metallic minerals – Solid fuels	CO ₂	177.4	0.2	96.1
1.A.1.c.	Energy industries – Manufacture of solid fuels and other energy industries	CO ₂	163.3	0.2	96.2
1.A.4.c.	Other sectors – Agriculture/forestry/fishing	CO ₂	148.2	0.1	96.4
1.B.2.b.ii.	Natural gas – Production and gathering	CH ₄	142.3	0.1	96.5
2.G.3.	Other product manufacture and use – N ₂ O from product uses	N ₂ O	112.5	0.1	96.6
5.D.	Waste – Wastewater treatment and discharge	N ₂ O	110.5	0.1	96.7
1.A.3.c.	Railways – Liquid fuels	CO ₂	108.2	0.1	96.8
1.A.2.f.	Non-metallic minerals – Gaseous fuels	CO ₂	102.3	0.1	96.9
1.B.2.d.	Other (please specify) – Geothermal	CH ₄	101.0	0.1	97.0
4(II).A.	Forest land – 4(II). Drainage & rewetting and other management of soils (CO ₂ , N ₂ O, CH ₄)	N ₂ O	98.7	0.1	97.1
3.B.1.b.	Option A – Non-dairy cattle	CH ₄	97.8	0.1	97.2
2.A.2.	Mineral industry – Lime production	CO ₂	96.2	0.1	97.3
1.A.2.a.	Iron and steel – Gaseous fuels	CO ₂	93.1	0.1	97.4
3.B(a).	(a). CH ₄ emissions – Sheep	CH ₄	91.9	0.1	97.5
2.B.8.	Chemical industry – Petrochemical and carbon black production	CH ₄	89.4	0.1	97.5
1.A.3.d.	Domestic navigation – Gas/diesel oil	CO ₂	87.1	0.1	97.6
3.B.5.	(b). N ₂ O and NMVOC emissions – Indirect N ₂ O emissions	N ₂ O	82.8	0.1	97.7
4.F.2.	Carbon stock change – Land converted to other land	CO ₂	82.4	0.1	97.8
5.C.	Waste – Incineration and open burning of waste	CO ₂	81.5	0.1	97.9
5.C.	Waste – Incineration and open burning of waste	CH ₄	80.4	0.1	97.9
4.E.1.	Carbon stock change – Settlements remaining settlements	CO ₂	79.8	0.1	98.0
4(III).A.	Forest land – 4(III). Direct & indirect N ₂ O emissions from N mineralization/immobilization	N ₂ O	79.8	0.1	98.1
1.A.3.b.	Transport – Road transportation	N ₂ O	73.4	0.1	98.2
3.D.1.b.	Direct N ₂ O emissions from managed soils – Organic N fertilizers	N ₂ O	73.3	0.1	98.2
2.F.4.	Product uses as substitutes for ODS – Aerosols	HFCs	67.9	0.1	98.3

CRT category code	IPCC category	Gas	2023 estimate (kt CO ₂ -e)	Level assessment (%)	Cumulative total (%)
1.B.1.a.ii.	Coal mining and handling – Surface mines	CH ₄	63.4	0.1	98.4
2.C.3.	Metal industry – Aluminium production	PFCs	60.9	0.1	98.4
1.A.4.c.	Other sectors – Agriculture/forestry/fishing	CO ₂	56.6	0.1	98.5
2.A.4.	Mineral industry – Other process uses of carbonates	CO ₂	53.0	0.1	98.5
1.A.2.g.viii.	Other – Other (please specify)	CO ₂	52.7	0.1	98.6
5.B.	Waste – Biological treatment of solid waste	CH ₄	52.3	0.0	98.6
1.A.2.f.	Non-metallic minerals – Liquid fuels	CO ₂	51.5	0.0	98.7
1.A.4.b.	Other sectors – Residential	CH ₄	50.0	0.0	98.7
1.B.2.c.ii.3.	Flaring – Combined	CO ₂	49.6	0.0	98.8
1.A.4.a.	Other sectors – Commercial/institutional	CO ₂	44.8	0.0	98.8
1.A.3.d.	Domestic navigation – Residual fuel oil	CO ₂	44.1	0.0	98.9
1.A.2.d.	Pulp, paper and print – Other fossil fuels	CO ₂	43.5	0.0	98.9
3.B(a).	(a). CH ₄ emissions – Swine	CH ₄	41.3	0.0	98.9
4.E.2.	Carbon stock change – Land converted to settlements	CO ₂	39.5	0.0	99.0
1.A.1.c.	Energy industries – Manufacture of solid fuels and other energy industries liquid fuels	CO ₂	38.8	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 A1.3.1(b) Results of the key category level analysis for 99 per cent of the gross emissions for New Zealand in 2023

CRT category code	IPCC category	Gas	2023 estimate (kt CO ₂ -e)	Level assessment (%)	Cumulative total (%)
3.A.1.a.	Option A – Dairy cattle	CH ₄	15,590.4	20.4	20.4
1.A.3.b.	Transport – Road transportation	CO ₂	12,510.8	16.4	36.8
3.A.2.	Enteric fermentation – Sheep	CH ₄	8,493.7	11.1	47.9
3.A.1.b.	Option A – Non-dairy cattle	CH ₄	7,125.9	9.3	57.2
3.D.1.c.	Direct N ₂ O emissions from managed soils – Urine and dung deposited by grazing animals	N ₂ O	3,151.8	4.1	61.3
5.A.	Waste – Solid waste disposal	CH ₄	2,256.8	3.0	64.3
1.A.1.a.	Energy industries – Public electricity and heat production	CO ₂	2,201.4	2.9	67.2
3.B.1.a.	Option A – Dairy cattle	CH ₄	1,519.0	2.0	69.2
2.C.1.	Metal industry – Iron and steel production	CO ₂	1,496.4	2.0	71.1
1.A.4.b.	Other sectors – Residential	CO ₂	1,339.2	1.8	72.9
1.A.2.c.	Chemicals – Gaseous fuels	CO ₂	1,305.9	1.7	74.6
1.A.2.e.	Food processing, beverages and tobacco – Solid fuels	CO ₂	1,257.8	1.6	76.2
1.A.3.a.	Domestic aviation – Jet kerosene	CO ₂	1,235.2	1.6	77.8
1.A.4.c.	Other sectors – Agriculture/forestry/fishing	CO ₂	1,176.5	1.5	79.4
1.A.2.e.	Food processing, beverages and tobacco – Gaseous fuels	CO ₂	1,116.7	1.5	80.8
3.D.1.a.	Direct N ₂ O emissions from managed soils – Inorganic N fertilizers	N ₂ O	1,109.9	1.5	82.3
2.F.1.	Product uses as substitutes for ODS – Refrigeration and air-conditioning	HFCs	1,011.4	1.3	83.6

CRT category code	IPCC category	Gas	2023 estimate (kt CO ₂ -e)	Level assessment (%)	Cumulative total (%)
3.D.2.a.	Indirect N ₂ O emissions from managed soils – Atmospheric deposition	N ₂ O	741.1	1.0	84.6
1.A.4.a.	Other sectors – Commercial/institutional	CO ₂	725.7	0.9	85.5
3.D.1.f.	Direct N ₂ O emissions from managed soils – Cultivation of organic soils	N ₂ O	590.0	0.8	86.3
2.C.3.	Metal industry – Aluminium production	CO ₂	543.0	0.7	87.0
1.A.1.a.	Energy industries – Public electricity and heat production	CO ₂	527.4	0.7	87.7
1.A.2.g.v.	Construction – Liquid fuels	CO ₂	519.1	0.7	88.4
3.D.2.b.	Indirect N ₂ O emissions from managed soils – Nitrogen leaching and run-off	N ₂ O	476.1	0.6	89.0
3.H.	Agriculture – Urea application	CO ₂	425.7	0.6	89.6
1.A.4.a.	Other sectors – Commercial/institutional	CO ₂	419.1	0.5	90.1
3.A.4.c.	Other livestock – Deer	CH ₄	406.2	0.5	90.7
1.A.4.b.	Other sectors – Residential	CO ₂	389.5	0.5	91.2
2.A.1.	Mineral industry – Cement production	CO ₂	379.0	0.5	91.7
1.B.2.d.	Other (please specify) – Geothermal	CO ₂	376.1	0.5	92.1
1.B.2.c.i.2.	Venting – Gas	CO ₂	350.8	0.5	92.6
1.A.2.g.iii.	Mining (excluding fuels) and quarrying – Liquid fuels	CO ₂	323.8	0.4	93.0
1.A.2.e.	Food processing, beverages and tobacco – Liquid fuels	CO ₂	317.5	0.4	93.4
5.D.	Waste – Wastewater treatment and discharge	CH ₄	290.7	0.4	93.8
3.G.	Agriculture – Liming	CO ₂	273.8	0.4	94.2
1.A.2.d.	Pulp, paper and print – Gaseous fuels	CO ₂	240.0	0.3	94.5
3.D.1.d.	Direct N ₂ O emissions from managed soils – Crop residues	N ₂ O	230.0	0.3	94.8
1.A.2.g.viii.	Other – Other (please specify)	CO ₂	224.1	0.3	95.1
1.A.2.f.	Non-metallic minerals – Solid fuels	CO ₂	177.4	0.2	95.3
1.A.1.c.	Energy industries – Manufacture of solid fuels and other energy industries	CO ₂	163.3	0.2	95.5
1.A.4.c.	Other sectors – Agriculture/forestry/fishing	CO ₂	148.2	0.2	95.7
1.B.2.b.ii.	Natural gas – Production and gathering	CH ₄	142.3	0.2	95.9
2.G.3.	Other product manufacture and use – N ₂ O from product uses	N ₂ O	112.5	0.1	96.1
5.D.	Waste – Wastewater treatment and discharge	N ₂ O	110.5	0.1	96.2
1.A.3.c.	Railways – Liquid fuels	CO ₂	108.2	0.1	96.4
1.A.2.f.	Non-metallic minerals – Gaseous fuels	CO ₂	102.3	0.1	96.5
1.B.2.d.	Other (please specify) – Geothermal	CH ₄	101.0	0.1	96.6
3.B.1.b.	Option A – Non-dairy cattle	CH ₄	97.8	0.1	96.7
2.A.2.	Mineral industry – Lime production	CO ₂	96.2	0.1	96.9
1.A.2.a.	Iron and steel – Gaseous fuels	CO ₂	93.1	0.1	97.0
3.B(a).	(a). CH ₄ emissions – Sheep	CH ₄	91.9	0.1	97.1
2.B.8.	Chemical industry – Petrochemical and carbon black production	CH ₄	89.4	0.1	97.2
1.A.3.d.	Domestic navigation – Gas/diesel oil	CO ₂	87.1	0.1	97.3
3.B.5.	(b). N ₂ O and NMVOC emissions – Indirect N ₂ O emissions	N ₂ O	82.8	0.1	97.5
5.C.	Waste – Incineration and open burning of waste	CO ₂	81.5	0.1	97.6
5.C.	Waste – Incineration and open burning of waste	CH ₄	80.4	0.1	97.7

CRT category code	IPCC category	Gas	2023 estimate (kt CO ₂ -e)	Level assessment (%)	Cumulative total (%)
1.A.3.b.	Transport – Road transportation	N ₂ O	73.4	0.1	97.8
3.D.1.b.	Direct N ₂ O emissions from managed soils – Organic N fertilizers	N ₂ O	73.3	0.1	97.9
2.F.4.	Product uses as substitutes for ODS – Aerosols	HFCs	67.9	0.1	97.9
1.B.1.a.ii.	Coal mining and handling – Surface mines	CH ₄	63.4	0.1	98.0
2.C.3.	Metal industry – Aluminium production	PFCs	60.9	0.1	98.1
1.A.4.c.	Other sectors – Agriculture/forestry/fishing	CO ₂	56.6	0.1	98.2
2.A.4.	Mineral industry – Other process uses of carbonates	CO ₂	53.0	0.1	98.3
1.A.2.g.viii.	Other – Other (please specify)	CO ₂	52.7	0.1	98.3
5.B.	Waste – Biological treatment of solid waste	CH ₄	52.3	0.1	98.4
1.A.2.f.	Non-metallic minerals – Liquid fuels	CO ₂	51.5	0.1	98.5
1.A.4.b.	Other sectors – Residential	CH ₄	50.0	0.1	98.5
1.B.2.c.ii.3.	Flaring – Combined	CO ₂	49.6	0.1	98.6
1.A.4.a.	Other sectors – Commercial/institutional	CO ₂	44.8	0.1	98.6
1.A.3.d.	Domestic navigation – Residual fuel oil	CO ₂	44.1	0.1	98.7
1.A.2.d.	Pulp, paper and print – Other fossil fuels	CO ₂	43.5	0.1	98.8
3.B(a).	(a). CH ₄ emissions – Swine	CH ₄	41.3	0.1	98.8
1.A.1.c.	Energy industries – Manufacture of solid fuels and other energy industries	CO ₂	38.8	0.1	98.9
1.A.2.d.	Pulp, paper and print – Liquid fuels	CO ₂	38.1	0.0	98.9
2.H.	Industrial processes and product use – Other	CO ₂	36.9	0.0	99.0
1.A.3.e.	Transport – Other transportation gaseous fuels	CO ₂	34.5	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 emissions and removals and gross emissions 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 -e)	Level assessment (%)	Cumulative total (%)
4.A.2.	Carbon stock change – Land converted to forest land	CO ₂	-18,100.0	19.0	19.0
3.A.2.	Enteric fermentation – Sheep	CH ₄	15,949.8	16.7	35.7
3.A.1.b.	Option A – Non-dairy cattle	CH ₄	7,400.7	7.8	43.5
3.A.1.a.	Option A – Dairy cattle	CH ₄	6,960.4	7.3	50.8
1.A.3.b.	Transport – Road transportation	CO ₂	6,519.0	6.8	57.6
4.A.1.	Carbon stock change – Forest land remaining forest land	CO ₂	-5,426.2	5.7	63.3
1.A.1.a.	Energy industries – Public electricity and heat production	CO ₂	2,999.6	3.1	66.5
3.D.1.c.	Direct N ₂ O emissions from managed soils – Urine and dung deposited by grazing animals	N ₂ O	2,650.3	2.8	69.3
5.A.	Waste – Solid waste disposal	CH ₄	2,630.4	2.8	72.0
4.G.	Land use, land-use change and forestry – Harvested wood products	CO ₂	-2,437.8	2.6	74.6
1.A.1.c.	Energy industries – Manufacture of solid fuels and other energy industries	CO ₂	1,702.8	1.8	76.4

CRT category code	IPCC category	Gas	1990 estimate (kt CO ₂ -e)	Level assessment (%)	Cumulative total (%)
2.C.1.	Metal industry – Iron and steel production	CO ₂	1,306.7	1.4	77.7
1.A.4.c.	Other sectors – Agriculture/forestry/fishing	CO ₂	1,071.9	1.1	78.9
1.A.2.e.	Food processing, beverages and tobacco – Solid fuels	CO ₂	938.6	1.0	79.8
1.A.3.a.	Domestic aviation – Jet kerosene	CO ₂	892.6	0.9	80.8
2.C.3.	Metal industry – Aluminium production	PFCs	818.0	0.9	81.6
1.A.4.b.	Other sectors – Residential	CO ₂	814.5	0.9	82.5
1.A.1.b.	Petroleum refining – Liquid fuels	CO ₂	778.9	0.8	83.3
1.A.2.g.viii.	Other – Other (please specify)	CO ₂	731.1	0.8	84.1
3.D.2.a.	Indirect N ₂ O emissions from managed soils – Atmospheric deposition	N ₂ O	636.8	0.7	84.7
3.D.1.f.	Direct N ₂ O emissions from managed soils – Cultivation of organic soils	N ₂ O	583.1	0.6	85.4
1.A.2.c.	Chemicals – Gaseous fuels	CO ₂	524.8	0.6	85.9
1.A.4.a.	Other sectors – Commercial/institutional	CO ₂	500.7	0.5	86.4
4.C.2.	Carbon stock change – Land converted to grassland	CO ₂	478.7	0.5	86.9
1.A.1.a.	Energy industries – Public electricity and heat production	CO ₂	474.8	0.5	87.4
3.B.1.a.	Option A – Dairy cattle	CH ₄	472.9	0.5	87.9
2.C.3.	Metal industry – Aluminium production	CO ₂	449.0	0.5	88.4
2.A.1.	Mineral industry – Cement production	CO ₂	448.7	0.5	88.9
3.A.4.c.	Other livestock – Deer	CH ₄	444.4	0.5	89.3
1.A.2.e.	Food processing, beverages and tobacco – Gaseous fuels	CO ₂	443.5	0.5	89.8
3.D.2.b.	Indirect N ₂ O emissions from managed soils – Nitrogen leaching and run-off	N ₂ O	392.6	0.4	90.2
1.A.2.f.	Non-metallic minerals – Solid fuels	CO ₂	382.9	0.4	90.6
4.B.1.	Carbon stock change – Cropland remaining cropland	CO ₂	352.9	0.4	91.0
1.A.2.d.	Pulp, paper and print – Gaseous fuels	CO ₂	347.6	0.4	91.3
1.A.4.b.	Other sectors – Residential	CO ₂	344.9	0.4	91.7
1.B.1.a.i.	Coal mining and handling – Underground mines	CH ₄	324.3	0.3	92.0
1.B.2.b.v.	Natural gas – Distribution	CH ₄	310.8	0.3	92.4
3.G.	Agriculture – Liming	CO ₂	296.5	0.3	92.7
1.A.2.e.	Food processing, beverages and tobacco – Liquid fuels	CO ₂	281.1	0.3	93.0
5.D.	Waste – Wastewater treatment and discharge	CH ₄	250.4	0.3	93.2
1.A.2.g.v.	Construction – Liquid fuels	CO ₂	237.3	0.2	93.5
1.A.4.a.	Other sectors – Commercial/institutional	CO ₂	235.2	0.2	93.7
1.A.3.d.	Domestic navigation – Residual fuel oil	CO ₂	232.9	0.2	94.0
1.B.2.d.	Other (please specify) – Geothermal	CO ₂	228.6	0.2	94.2
4.C.1.	Carbon stock change – Grassland remaining grassland	CO ₂	224.6	0.2	94.5
3.A.4.d.	Other livestock – Goats	CH ₄	220.2	0.2	94.7
3.D.1.a.	Direct N ₂ O emissions from managed soils – Inorganic N fertilizers	N ₂ O	204.8	0.2	94.9
1.A.4.b.	Other sectors – Residential	CO ₂	184.9	0.2	95.1
1.B.2.b.ii.	Natural gas – Production and gathering	CH ₄	160.7	0.2	95.3
3.B(a).	(a). CH ₄ emissions – Sheep	CH ₄	160.1	0.2	95.4

CRT category code	IPCC category	Gas	1990 estimate (kt CO ₂ -e)	Level assessment (%)	Cumulative total (%)
3.D.1.d.	Direct N ₂ O emissions from managed soils – Crop residues	N ₂ O	156.0	0.2	95.6
5.C.	Waste – Incineration and open burning of waste	CO ₂	153.3	0.2	95.8
2.B.10.	Chemical industry – Other	CO ₂	152.3	0.2	95.9
1.A.4.a.	Other sectors – Commercial/institutional	CO ₂	142.2	0.1	96.1
1.A.3.b.	Transport – Road transportation	CO ₂	140.3	0.1	96.2
5.C.	Waste – Incineration and open burning of waste	CH ₄	140.0	0.1	96.4
1.B.2.c.i.3.	Venting – Combined	CH ₄	122.2	0.1	96.5
4.B.2.	Carbon stock change – Land converted to cropland	CO ₂	118.7	0.1	96.6
1.A.2.a.	Iron and steel – Gaseous fuels	CO ₂	116.2	0.1	96.7
1.B.2.c.ii.3.	Flaring – Combined	CO ₂	114.1	0.1	96.9
4(III).A.	Forest land – 4(III). Direct & indirect N ₂ O emissions from N mineralization/immobilization	N ₂ O	111.2	0.1	97.0
1.A.2.d.	Pulp, paper and print – Solid fuels	CO ₂	109.5	0.1	97.1
1.B.2.c.i.2.	Venting – Gas	CO ₂	109.3	0.1	97.2
1.A.4.c.	Other sectors – Agriculture/forestry/fishing	CO ₂	105.8	0.1	97.3
3.B.1.b.	Option A – Non-dairy cattle	CH ₄	101.5	0.1	97.4
1.A.2.g.iii.	Mining (excluding fuels) and quarrying – Liquid fuels	CO ₂	94.4	0.1	97.5
2.G.3.	Other product manufacture and use – N ₂ O from product uses	N ₂ O	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 ₂ O	79.4	0.1	97.9
1.A.3.c.	Railways – Liquid fuels	CO ₂	78.4	0.1	97.9
5.D.	Waste – Wastewater treatment and discharge	N ₂ O	72.9	0.1	98.0
1.B.2.c.ii.3.	Flaring – Combined	CH ₄	72.4	0.1	98.1
4(II).A.	Forest land – 4(II). Drainage & rewetting and other management of soils (CO ₂ , N ₂ O, CH ₄)	N ₂ O	67.0	0.1	98.2
4.E.1.	Carbon stock change – Settlements remaining settlements	CO ₂	66.8	0.1	98.2
3.B(a).	(a). CH ₄ emissions – Swine	CH ₄	66.2	0.1	98.3
1.A.2.f.	Non-metallic minerals – Gaseous fuels	CO ₂	64.1	0.1	98.4
1.B.2.d.	Other (please specify) – Geothermal	CH ₄	61.4	0.1	98.4
1.A.2.g.vi.	Textile and leather – Gaseous fuels	CO ₂	58.9	0.1	98.5
4(IV).C.	Grassland – 4(IV). Biomass burning (CO ₂ , CH ₄ , N ₂ O)	CH ₄	57.1	0.1	98.6
1.A.4.b.	Other sectors – Residential	CH ₄	54.2	0.1	98.6
1.A.2.g.viii.	Other – 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	0.1	98.8
3.A.4.e.	Other livestock – Horses	CH ₄	47.4	0.0	98.8
4(III).C.	Grassland – 4(III). Direct & indirect N ₂ O emissions from N mineralization/immobilization	N ₂ O	47.1	0.0	98.9
1.A.2.f.	Non-metallic minerals – Liquid fuels	CO ₂	46.0	0.0	98.9
1.B.1.a.ii.	Coal mining and handling – Surface mines	CH ₄	43.1	0.0	99.0
1.A.2.g.i.	Other – 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 for New Zealand in 1990 included for reference only

CRT category code	IPCC category	Gas	1990 estimate (kt CO ₂ -e)	Level assessment (%)	Cumulative total (%)
3.A.2.	Enteric fermentation – Sheep	CH ₄	15,949.8	23.6	23.6
3.A.1.b.	Option A – Non-dairy cattle	CH ₄	7,400.7	10.9	34.5
3.A.1.a.	Option A – Dairy cattle	CH ₄	6,960.4	10.3	44.8
1.A.3.b.	Transport – Road transportation	CO ₂	6,519.0	9.6	54.4
1.A.1.a.	Energy industries – Public electricity and heat production	CO ₂	2,999.6	4.4	58.9
3.D.1.c.	Direct N ₂ O emissions from managed soils – Urine and dung deposited by grazing animals	N ₂ O	2,650.3	3.9	62.8
5.A.	Waste – Solid waste disposal	CH ₄	2,630.4	3.9	66.7
1.A.1.c.	Energy industries – Manufacture of solid fuels and other energy industries	CO ₂	1,702.8	2.5	69.2
2.C.1.	Metal industry – Iron and steel production	CO ₂	1,306.7	1.9	71.1
1.A.4.c.	Other sectors – Agriculture/forestry/fishing	CO ₂	1,071.9	1.6	72.7
1.A.2.e.	Food processing, beverages and tobacco – Solid fuels	CO ₂	938.6	1.4	74.1
1.A.3.a.	Domestic aviation – Jet kerosene	CO ₂	892.6	1.3	75.4
2.C.3.	Metal industry – Aluminium production	PFCs	818.0	1.2	76.6
1.A.4.b.	Other sectors – Residential	CO ₂	814.5	1.2	77.8
1.A.1.b.	Petroleum refining – Liquid fuels	CO ₂	778.9	1.2	79.0
1.A.2.g.viii.	Other – Other (please specify)	CO ₂	731.1	1.1	80.0
3.D.2.a.	Indirect N ₂ O emissions from managed soils – Atmospheric deposition	N ₂ O	636.8	0.9	81.0
3.D.1.f.	Direct N ₂ O emissions from managed soils – Cultivation of organic soils	N ₂ O	583.1	0.9	81.8
1.A.2.c.	Chemicals – Gaseous fuels	CO ₂	524.8	0.8	82.6
1.A.4.a.	Other sectors – Commercial/institutional	CO ₂	500.7	0.7	83.4
1.A.1.a.	Energy industries – Public electricity and heat production	CO ₂	474.8	0.7	84.1
3.B.1.a.	Option A – Dairy cattle	CH ₄	472.9	0.7	84.8
2.C.3.	Metal industry – Aluminium production	CO ₂	449.0	0.7	85.4
2.A.1.	Mineral industry – Cement production	CO ₂	448.7	0.7	86.1
3.A.4.c.	Other livestock – Deer	CH ₄	444.4	0.7	86.7
1.A.2.e.	Food processing, beverages and tobacco – Gaseous fuels	CO ₂	443.5	0.7	87.4
3.D.2.b.	Indirect N ₂ O emissions from managed soils – Nitrogen leaching and run-off	N ₂ O	392.6	0.6	88.0
1.A.2.f.	Non-metallic minerals – Solid fuels	CO ₂	382.9	0.6	88.5
1.A.2.d.	Pulp, paper and print – Gaseous fuels	CO ₂	347.6	0.5	89.0
1.A.4.b.	Other sectors – Residential	CO ₂	344.9	0.5	89.6
1.B.1.a.i.	Coal mining and handling – Underground mines	CH ₄	324.3	0.5	90.0
1.B.2.b.v.	Natural gas – Distribution	CH ₄	310.8	0.5	90.5
3.G.	Agriculture – Liming	CO ₂	296.5	0.4	90.9
1.A.2.e.	Food processing, beverages and tobacco – Liquid fuels	CO ₂	281.1	0.4	91.4
5.D.	Waste – Wastewater treatment and discharge	CH ₄	250.4	0.4	91.7
1.A.2.g.v.	Construction – Liquid fuels	CO ₂	237.3	0.4	92.1
1.A.4.a.	Other sectors – Commercial/institutional	CO ₂	235.2	0.3	92.4
1.A.3.d.	Domestic navigation – Residual fuel oil	CO ₂	232.9	0.3	92.8
1.B.2.d.	Other (please specify) – Geothermal	CO ₂	228.6	0.3	93.1

CRT category code	IPCC category	Gas	1990 estimate (kt CO ₂ -e)	Level assessment (%)	Cumulative total (%)
3.A.4.d.	Other livestock – Goats	CH₄	220.2	0.3	93.4
3.D.1.a.	Direct N₂O emissions from managed soils – Inorganic N fertilizers	N₂O	204.8	0.3	93.7
1.A.4.b.	Other sectors – Residential	CO₂	184.9	0.3	94.0
1.B.2.b.ii.	Natural gas – Production and gathering	CH₄	160.7	0.2	94.2
3.B(a).	(a). CH₄ emissions – Sheep	CH₄	160.1	0.2	94.5
3.D.1.d.	Direct N₂O emissions from managed soils – Crop residues	N₂O	156.0	0.2	94.7
5.C.	Waste – Incineration and open burning of waste	CO₂	153.3	0.2	94.9
2.B.10.	Chemical industry – Other	CO₂	152.3	0.2	95.2
1.A.4.a.	Other sectors – Commercial/institutional	CO ₂	142.2	0.2	95.4
1.A.3.b.	Transport – Road transportation	CO ₂	140.3	0.2	95.6
5.C.	Waste – Incineration and open burning of waste	CH ₄	140.0	0.2	95.8
1.B.2.c.i.3.	Venting – Combined	CH ₄	122.2	0.2	96.0
1.A.2.a.	Iron and steel – Gaseous fuels	CO ₂	116.2	0.2	96.1
1.B.2.c.ii.3.	Flaring – Combined	CO ₂	114.1	0.2	96.3
1.A.2.d.	Pulp, paper and print – Solid fuels	CO ₂	109.5	0.2	96.5
1.B.2.c.i.2.	Venting – Gas	CO ₂	109.3	0.2	96.6
1.A.4.c.	Other sectors – Agriculture/forestry/fishing	CO ₂	105.8	0.2	96.8
3.B.1.b.	Option A – Non-dairy cattle	CH ₄	101.5	0.1	96.9
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 ₂ O from product uses	N ₂ O	88.8	0.1	97.2
2.A.2.	Mineral industry – Lime production	CO ₂	82.6	0.1	97.3
1.A.3.b.	Transport – Road transportation	CH ₄	81.7	0.1	97.4
1.A.3.b.	Transport – Road transportation	N ₂ O	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 ₂ O	72.9	0.1	97.8
1.B.2.c.ii.3.	Flaring – Combined	CH ₄	72.4	0.1	97.9
3.B(a).	(a). CH ₄ emissions – Swine	CH ₄	66.2	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	98.3
1.A.2.g.viii.	Other – Other (please specify)	CO ₂	52.3	0.1	98.4
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.e.	Other livestock – Horses	CH ₄	47.4	0.1	98.6
1.A.2.f.	Non-metallic minerals – Liquid fuels	CO ₂	46.0	0.1	98.7
1.B.1.a.ii.	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	98.8
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	98.9
3.D.1.b.	Direct N ₂ O emissions from managed soils – Organic N fertilizers	N ₂ O	31.4	0.0	99.0
2.B.8.	Chemical industry – Petrochemical and carbon black production	CH ₄	30.9	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 A1.3.3(a) and table A1.3.3(b) present results of the key category trend analysis of the net emissions and removals and gross emissions in 1990 and 2023 respectively.

Table A1.3.3(a) Results of the key category trend analysis for 99 per cent of the net emissions for New Zealand in 1990 and 2023

CRT category code	IPCC category	Gas	1990 estimate (kt CO ₂ -e)	2023 estimate (kt CO ₂ -e)	Trend assessment	Absolute contribution to trend (%)	Absolute cumulative total (%)
4.A.1.	Carbon stock change – Forest land remaining forest land	CO ₂	-5,426.2	-16,012.6	0.128	16.2	16.2
3.A.2.	Enteric fermentation – Sheep	CH ₄	15,949.8	8,493.7	0.128	16.2	32.4
4.A.2.	Carbon stock change – Land converted to forest land	CO ₂	-18,100.0	-2,475.7	0.108	13.6	46.0
3.A.1.a.	Option A – Dairy cattle	CH ₄	6,960.4	15,590.4	0.069	8.7	54.7
4.G.	Land use, land-use change and forestry – Harvested wood products	CO ₂	-2,437.8	-5,808.3	0.043	5.4	60.1
1.A.3.b.	Transport – Road transportation	CO ₂	6,519.0	12,510.8	0.043	5.4	65.5
3.A.1.b.	Option A – Non-dairy cattle	CH ₄	7,400.7	7,125.9	0.026	3.3	68.7
1.A.1.c.	Energy industries – Manufacture of solid fuels and other energy industries	CO ₂	1,702.8	163.3	0.021	2.7	71.5
1.A.1.a.	Energy industries – Public electricity and heat production	CO ₂	2,999.6	2,201.4	0.018	2.2	73.7
5.A.	Waste – Solid waste disposal	CH ₄	2,630.4	2,256.8	0.012	1.5	75.2
4.C.1.	Carbon stock change – Grassland remaining grassland	CO ₂	224.6	1,310.7	0.011	1.4	76.6
2.F.1.	Product uses as substitutes for ODS – Refrigeration and air-conditioning	HFCs	0.0	1,011.4	0.011	1.3	77.9
1.A.1.b.	Petroleum refining – Liquid fuels	CO ₂	778.9	0.0	0.011	1.3	79.3
2.C.3.	Metal industry – Aluminium production	PFCs	818.0	60.9	0.010	1.3	80.6
4.C.2.	Carbon stock change – Land converted to grassland	CO ₂	478.7	1,543.4	0.010	1.2	81.8
3.B.1.a.	Option A – Dairy cattle	CH ₄	472.9	1,519.0	0.010	1.2	83.0
1.A.2.g.viii.	Other – Other (please specify)	CO ₂	731.1	52.7	0.009	1.2	84.2
3.D.1.a.	Direct N ₂ O emissions from managed soils – Inorganic N fertilizers	N ₂ O	204.8	1,109.9	0.009	1.1	85.3
1.A.2.c.	Chemicals – Gaseous fuels	CO ₂	524.8	1,305.9	0.007	0.8	86.2
1.A.2.e.	Food processing, beverages and tobacco – Gaseous fuels	CO ₂	443.5	1,116.7	0.006	0.7	86.9
1.A.4.b.	Other sectors – Residential	CO ₂	344.9	11.8	0.005	0.6	87.5
1.B.1.a.i.	Coal mining and handling – Underground mines	CH ₄	324.3	0.0	0.004	0.6	88.0
3.H.	Agriculture – Urea application	CO ₂	39.2	425.7	0.004	0.5	88.5
1.B.2.b.v.	Natural gas – Distribution	CH ₄	310.8	29.9	0.004	0.5	89.0
1.A.2.f.	Non-metallic minerals – Solid fuels	CO ₂	382.9	177.4	0.003	0.4	89.4
4.B.2.	Carbon stock change – Land converted to cropland	CO ₂	118.7	466.4	0.003	0.4	89.8

CRT category code	IPCC category	Gas	1990 estimate (kt CO ₂ -e)	2023 estimate (kt CO ₂ -e)	Trend assessment	Absolute contribution to trend (%)	Absolute cumulative total (%)
3.D.1.c.	Direct N ₂ O emissions from managed soils – Urine and dung deposited by grazing animals	N ₂ O	2,650.3	3,151.8	0.003	0.4	90.2
1.A.4.b.	Other sectors – Residential	CO ₂	814.5	1,339.2	0.003	0.4	90.6
3.A.4.d.	Other livestock – Goats	CH ₄	220.2	19.6	0.003	0.4	90.9
1.A.3.d.	Domestic navigation – Residual fuel oil	CO ₂	232.9	44.1	0.003	0.3	91.3
1.A.4.c.	Other sectors – Agriculture/forestry/fishing	CO ₂	1,071.9	1,176.5	0.002	0.3	91.6
1.A.2.g.v.	Construction – Liquid fuels	CO ₂	237.3	519.1	0.002	0.3	91.9
1.A.2.d.	Pulp, paper and print – Gaseous fuels	CO ₂	347.6	240.0	0.002	0.3	92.1
1.B.2.c.i.2.	Venting – Gas	CO ₂	109.3	350.8	0.002	0.3	92.4
2.A.1.	Mineral industry – Cement production	CO ₂	448.7	379.0	0.002	0.3	92.7
4.B.1.	Carbon stock change – Cropland remaining cropland	CO ₂	352.9	256.1	0.002	0.3	92.9
1.A.2.g.iii.	Mining (excluding fuels) and quarrying – Liquid fuels	CO ₂	94.4	323.8	0.002	0.3	93.2
2.C.1.	Metal industry – Iron and steel production	CO ₂	1,306.7	1,496.4	0.002	0.3	93.5
2.B.10.	Chemical industry – Other	CO ₂	152.3	14.4	0.002	0.2	93.7
1.A.3.b.	Transport – Road transportation	CO ₂	140.3	0.0	0.002	0.2	94.0
3.A.4.c.	Other livestock – Deer	CH ₄	444.4	406.2	0.002	0.2	94.2
3.D.1.f.	Direct N ₂ O emissions from managed soils – Cultivation of organic soils	N ₂ O	583.1	590.0	0.002	0.2	94.4
1.A.2.g.viii.	Other – Other (please specify)	CO ₂	52.3	224.1	0.002	0.2	94.6
1.A.4.b.	Other sectors – Residential	CO ₂	184.9	389.5	0.002	0.2	94.8
1.A.4.a.	Other sectors – Commercial/institutional	CO ₂	142.2	44.8	0.001	0.2	95.0
1.B.2.c.i.3.	Venting – Combined	CH ₄	122.2	24.2	0.001	0.2	95.2
1.A.2.d.	Pulp, paper and print – Solid fuels	CO ₂	109.5	11.6	0.001	0.2	95.4
5.C.	Waste – Incineration and open burning of waste	CO ₂	153.3	81.5	0.001	0.2	95.5
3.B(a).	(a). CH ₄ emissions – Sheep	CH ₄	160.1	91.9	0.001	0.2	95.7
1.A.4.a.	Other sectors – Commercial/institutional	CO ₂	235.2	419.1	0.001	0.2	95.8
3.G.	Agriculture – Liming	CO ₂	296.5	273.8	0.001	0.1	96.0
1.A.4.c.	Other sectors – Agriculture/forestry/fishing	CO ₂	35.1	148.2	0.001	0.1	96.1
5.C.	Waste – Incineration and open burning of waste	CH ₄	140.0	80.4	0.001	0.1	96.2
1.B.2.c.ii.3.	Flaring – Combined	CO ₂	114.1	49.6	0.001	0.1	96.4
1.A.3.b.	Transport – Road transportation	CH ₄	81.7	15.4	0.001	0.1	96.5
1.A.1.a.	Energy industries – Public electricity and heat production	CO ₂	474.8	527.4	0.001	0.1	96.6

CRT category code	IPCC category	Gas	1990 estimate (kt CO ₂ -e)	2023 estimate (kt CO ₂ -e)	Trend assessment	Absolute contribution to trend (%)	Absolute cumulative total (%)
3.D.2.a.	Indirect N ₂ O emissions from managed soils – Atmospheric deposition	N ₂ O	636.8	741.1	0.001	0.1	96.7
1.B.2.c.ii.3.	Flaring – Combined	CH ₄	72.4	10.8	0.001	0.1	96.8
1.A.4.c.	Other sectors – Agriculture/forestry/fishing	CO ₂	105.8	56.6	0.001	0.1	96.9
1.B.2.d.	Other (please specify) – Geothermal	CO ₂	228.6	376.1	0.001	0.1	97.0
1.A.3.a.	Domestic aviation – Jet kerosene	CO ₂	892.6	1,235.2	0.001	0.1	97.1
1.A.4.a.	Other sectors – Commercial/institutional	CO ₂	500.7	725.7	0.001	0.1	97.2
1.A.3.d.	Domestic navigation – Gas/Diesel oil	CO ₂	12.7	87.1	0.001	0.1	97.3
2.F.4.	Product uses as substitutes for ODS – Aerosols	HFCs	0.0	67.9	0.001	0.1	97.4
1.B.2.b.ii.	Natural gas – Production and gathering	CH ₄	160.7	142.3	0.001	0.1	97.5
4(III).A.	Forest land – 4(III). Direct & indirect N ₂ O emissions from N mineralization/immobilization	N ₂ O	111.2	79.8	0.001	0.1	97.6
4.F.2.	Carbon stock change – Land converted to other land	CO ₂	14.7	82.4	0.001	0.1	97.7
1.A.2.g.vi.	Textile and leather – Gaseous fuels	CO ₂	58.9	14.2	0.001	0.1	97.8
4(IV).C.	Grassland – 4(IV). Biomass burning (CO ₂ , CH ₄ , N ₂ O)	CH ₄	57.1	15.3	0.001	0.1	97.8
1.A.2.a.	Iron and steel – Gaseous fuels	CO ₂	116.2	93.1	0.001	0.1	97.9
4(III).C.	Grassland – 4(III). Direct & indirect N ₂ O emissions from N mineralization/immobilization	N ₂ O	47.1	6.8	0.001	0.1	98.0
2.B.8.	Chemical industry – Petrochemical and carbon black production	CH ₄	30.9	89.4	0.001	0.1	98.1
5.B.	Waste – Biological treatment of solid waste	CH ₄	3.1	52.3	0.001	0.1	98.1
1.A.2.e.	Food processing, beverages and tobacco – Liquid fuels	CO ₂	281.1	317.5	0.000	0.1	98.2
3.A.4.e.	Other livestock – Horses	CH ₄	47.4	15.7	0.000	0.1	98.2
3.B(a).	(a). CH ₄ emissions – Swine	CH ₄	66.2	41.3	0.000	0.1	98.3
3.B.5.	(b). N ₂ O and NMVOC emissions – Indirect N ₂ O emissions	N ₂ O	30.1	82.8	0.000	0.1	98.4
1.A.2.d.	Pulp, paper and print – Other fossil fuels	CO ₂	0.0	43.5	0.000	0.1	98.4
1.A.2.g.i.	Manufacturing of machinery – Gaseous fuels	CO ₂	41.8	12.7	0.000	0.1	98.5
1.A.2.e.	Food processing, beverages and tobacco – Solid fuels	CO ₂	938.6	1,257.8	0.000	0.1	98.5
2.C.3.	Metal industry – Aluminium production	CO ₂	449.0	543.0	0.000	0.1	98.6
1.A.1.c.	Energy industries – Manufacture of solid fuels and other energy industries	CO ₂	0.0	38.8	0.000	0.1	98.6
1.A.4.b.	Other sectors – Residential	CH ₄	30.6	1.0	0.000	0.1	98.7

CRT category code	IPCC category	Gas	1990 estimate (kt CO ₂ -e)	2023 estimate (kt CO ₂ -e)	Trend assessment	Absolute contribution to trend (%)	Absolute cumulative total (%)
1.A.3.a.	Domestic aviation – Aviation gasoline	CO ₂	47.7	23.9	0.000	0.1	98.7
5.D.	Waste – Wastewater treatment and discharge	CH ₄	250.4	290.7	0.000	0.0	98.8
3.B.1.b.	Option A – Non-dairy cattle	CH ₄	101.5	97.8	0.000	0.0	98.8
3.D.2.b.	Indirect N ₂ O emissions from managed soils – Nitrogen leaching and run-off	N ₂ O	392.6	476.1	0.000	0.0	98.9
1.A.2.f.	Non-metallic minerals – Other fossil fuels	CO ₂	0.0	32.8	0.000	0.0	98.9
3.D.1.b.	Direct N ₂ O emissions from managed soils – Organic N fertilizers	N ₂ O	31.4	73.3	0.000	0.0	98.9
1.A.3.b.	Transport – Road transportation	N ₂ O	79.4	73.4	0.000	0.0	99.0
3.D.1.d.	Direct N ₂ O emissions from managed soils – Crop residues	N ₂ O	156.0	230.0	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 2023

CRT category code	IPCC category	Gas	1990 estimate (kt CO ₂ -e)	2023 estimate (kt CO ₂ -e)	Trend assessment	Absolute contribution to trend (%)	Absolute cumulative total (%)
3.A.2.	Enteric fermentation – Sheep	CH ₄	15,949.8	8,493.7	0.141	22.6	22.6
3.A.1.a.	Option A – Dairy cattle	CH ₄	6,960.4	15,590.4	0.114	18.4	41.0
1.A.3.b.	Transport – Road transportation	CO ₂	6,519.0	12,510.8	0.076	12.2	53.3
1.A.1.c.	Energy industries – Manufacture of solid fuels and other energy industries	CO ₂	1,702.8	163.3	0.026	4.2	57.4
3.A.1.b.	Option A – Non-dairy cattle	CH ₄	7,400.7	7,125.9	0.018	2.9	60.4
1.A.1.a.	Energy industries – Public electricity and heat production	CO ₂	2,999.6	2,201.4	0.018	2.8	63.2
2.F.1.	Product uses as substitutes for ODS – Refrigeration and air-conditioning	HFCs	0.0	1,011.4	0.015	2.4	65.6
3.B.1.a.	Option A – Dairy cattle	CH ₄	472.9	1,519.0	0.015	2.3	67.9
1.A.1.b.	Petroleum refining – Liquid fuels	CO ₂	778.9	0.0	0.013	2.1	70.0
3.D.1.a.	Direct N ₂ O emissions from managed soils – Inorganic N fertilizers	N ₂ O	204.8	1,109.9	0.013	2.1	72.1
2.C.3.	Metal industry – Aluminium production	PFCs	818.0	60.9	0.013	2.1	74.2
1.A.2.g.viii.	Other – Other (please specify)	CO ₂	731.1	52.7	0.011	1.8	76.0
1.A.2.c.	Chemicals – Gaseous fuels	CO ₂	524.8	1,305.9	0.011	1.7	77.7
5.A.	Waste – Solid waste disposal	CH ₄	2,630.4	2,256.8	0.011	1.7	79.4
1.A.2.e.	Food processing, beverages and tobacco – Gaseous fuels	CO ₂	443.5	1,116.7	0.009	1.5	80.9

CRT category code	IPCC category	Gas	1990 estimate (kt CO ₂ -e)	2023 estimate (kt CO ₂ -e)	Trend assessment	Absolute contribution to trend (%)	Absolute cumulative total (%)
1.A.4.b.	Other sectors – Residential	CO ₂	814.5	1,339.2	0.006	1.0	81.8
3.H.	Agriculture – Urea application	CO ₂	39.2	425.7	0.006	0.9	82.8
1.A.4.b.	Other sectors – Residential	CO ₂	344.9	11.8	0.006	0.9	83.7
1.B.1.a.i.	Coal mining and handling – Underground mines	CH ₄	324.3	0.0	0.005	0.9	84.5
1.B.2.b.v.	Natural gas – Distribution	CH ₄	310.8	29.9	0.005	0.8	85.3
1.A.2.f.	Non-metallic minerals – Solid fuels	CO ₂	382.9	177.4	0.004	0.6	85.9
1.A.2.g.v.	Construction – Liquid fuels	CO ₂	237.3	519.1	0.004	0.6	86.5
3.A.4.d.	Other livestock – Goats	CH ₄	220.2	19.6	0.003	0.5	87.0
1.B.2.c.i.2.	Venting – Gas	CO ₂	109.3	350.8	0.003	0.5	87.6
1.A.3.a.	Domestic aviation – Jet kerosene	CO ₂	892.6	1,235.2	0.003	0.5	88.1
1.A.3.d.	Domestic navigation – Residual fuel oil	CO ₂	232.9	44.1	0.003	0.5	88.6
1.A.2.g.iii.	Mining (excluding fuels) and quarrying – Liquid fuels	CO ₂	94.4	323.8	0.003	0.5	89.2
1.A.2.e.	Food processing, beverages and tobacco – Solid fuels	CO ₂	938.6	1,257.8	0.003	0.5	89.6
1.A.4.b.	Other sectors – Residential	CO ₂	184.9	389.5	0.003	0.4	90.1
1.A.2.g.viii.	Other – Other (please specify)	CO ₂	52.3	224.1	0.002	0.4	90.4
1.A.4.a.	Other sectors – Commercial/institutional	CO ₂	500.7	725.7	0.002	0.4	90.8
3.D.1.c.	Direct N ₂ O emissions from managed soils – Urine and dung deposited by grazing animals	N ₂ O	2,650.3	3,151.8	0.002	0.4	91.2
1.A.3.b.	Transport – Road transportation	CO ₂	140.3	0.0	0.002	0.4	91.6
2.B.10.	Chemical industry – Other	CO ₂	152.3	14.4	0.002	0.4	92.0
1.A.4.a.	Other sectors – Commercial/institutional	CO ₂	235.2	419.1	0.002	0.4	92.3
1.A.2.d.	Pulp, paper and print – Gaseous fuels	CO ₂	347.6	240.0	0.002	0.4	92.7
2.A.1.	Mineral industry – Cement production	CO ₂	448.7	379.0	0.002	0.3	93.0
1.B.2.d.	Other (please specify) – Geothermal	CO ₂	228.6	376.1	0.002	0.3	93.3
1.A.4.a.	Other sectors – Commercial/institutional	CO ₂	142.2	44.8	0.002	0.3	93.5
1.B.2.c.i.3.	Venting – Combined	CH ₄	122.2	24.2	0.002	0.3	93.8
1.A.2.d.	Pulp, paper and print – Solid fuels	CO ₂	109.5	11.6	0.002	0.3	94.1
1.A.4.c.	Other sectors – Agriculture/forestry/fishing	CO ₂	35.1	148.2	0.002	0.3	94.3
3.A.4.c.	Other livestock – Deer	CH ₄	444.4	406.2	0.001	0.2	94.6
5.C.	Waste – Incineration and open burning of waste	CO ₂	153.3	81.5	0.001	0.2	94.8
3.B(a).	(a). CH ₄ emissions – Sheep	CH ₄	160.1	91.9	0.001	0.2	95.0

CRT category code	IPCC category	Gas	1990 estimate (kt CO ₂ -e)	2023 estimate (kt CO ₂ -e)	Trend assessment	Absolute contribution to trend (%)	Absolute cumulative total (%)
1.B.2.c.ii.3.	Flaring – Combined	CO ₂	114.1	49.6	0.001	0.2	95.2
5.C.	Waste – Incineration and open burning of waste	CH ₄	140.0	80.4	0.001	0.2	95.4
1.A.3.b.	Transport – Road transportation	CH ₄	81.7	15.4	0.001	0.2	95.6
1.A.3.d.	Domestic navigation – Gas/diesel oil	CO ₂	12.7	87.1	0.001	0.2	95.7
1.B.2.c.ii.3.	Flaring – Combined	CH ₄	72.4	10.8	0.001	0.2	95.9
3.D.1.f.	Direct N ₂ O emissions from managed soils – Cultivation of organic soils	N ₂ O	583.1	590.0	0.001	0.2	96.1
2.F.4.	Product uses as substitutes for ODS – Aerosols	HFCs	0.0	67.9	0.001	0.2	96.2
1.A.4.c.	Other sectors – Agriculture/forestry/fishing	CO ₂	105.8	56.6	0.001	0.1	96.4
3.G.	Agriculture – Liming	CO ₂	296.5	273.8	0.001	0.1	96.5
2.B.8.	Chemical industry – Petrochemical and carbon black production	CH ₄	30.9	89.4	0.001	0.1	96.6
3.D.1.d.	Direct N ₂ O emissions from managed soils – Crop residues	N ₂ O	156.0	230.0	0.001	0.1	96.8
1.A.2.g.vi.	Textile and leather – Gaseous fuels	CO ₂	58.9	14.2	0.001	0.1	96.9
5.B.	Waste – Biological treatment of solid waste	CH ₄	3.1	52.3	0.001	0.1	97.0
3.B.5.	(b). N ₂ O and NMVOC emissions – Indirect N ₂ O emissions	N ₂ O	30.1	82.8	0.001	0.1	97.1
1.A.2.d.	Pulp, paper and print – Other fossil fuels	CO ₂	0.0	43.5	0.001	0.1	97.2
1.B.2.b.ii.	Natural gas – Production and gathering	CH ₄	160.7	142.3	0.001	0.1	97.3
1.A.1.c.	Energy industries – Manufacture of solid fuels and other energy industries	CO ₂	0.0	38.8	0.001	0.1	97.4
1.A.2.a.	Iron and steel – Gaseous fuels	CO ₂	116.2	93.1	0.001	0.1	97.5
3.D.1.b.	Direct N ₂ O emissions from managed soils – Organic N fertilizers	N ₂ O	31.4	73.3	0.001	0.1	97.6
3.A.4.e.	Other livestock – Horses	CH ₄	47.4	15.7	0.001	0.1	97.7
2.C.3.	Metal industry – Aluminium production	CO ₂	449.0	543.0	0.001	0.1	97.8
1.A.2.g.i.	Manufacturing of machinery – Gaseous fuels	CO ₂	41.8	12.7	0.001	0.1	97.9
1.A.4.c.	Other sectors – Agriculture/forestry/fishing	CO ₂	1,071.9	1,176.5	0.000	0.1	97.9
1.A.4.b.	Other sectors – Residential	CH ₄	30.6	1.0	0.000	0.1	98.0
3.B(a).	(a). CH ₄ emissions – Swine	CH ₄	66.2	41.3	0.000	0.1	98.1
3.D.2.b.	Indirect N ₂ O emissions from managed soils – Nitrogen leaching and run-off	N ₂ O	392.6	476.1	0.000	0.1	98.2
1.A.2.f.	Non-metallic minerals – Other fossil fuels	CO ₂	0.0	32.8	0.000	0.1	98.2

CRT category code	IPCC category	Gas	1990 estimate (kt CO ₂ -e)	2023 estimate (kt CO ₂ -e)	Trend assessment	Absolute contribution to trend (%)	Absolute cumulative total (%)
1.B.2.d.	Other (please specify) – Geothermal	CH ₄	61.4	101.0	0.000	0.1	98.3
1.A.2.f.	Non-metallic minerals – Gaseous fuels	CO ₂	64.1	102.3	0.000	0.1	98.4
1.A.3.a.	Domestic aviation – Aviation gasoline	CO ₂	47.7	23.9	0.000	0.1	98.5
1.A.3.e.	Transport – Other transportation	CO ₂	5.5	34.5	0.000	0.1	98.5
5.D.	Waste – Wastewater treatment and discharge	N ₂ O	72.9	110.5	0.000	0.1	98.6
5.B.	Waste – Biological treatment of solid waste	N ₂ O	1.7	29.3	0.000	0.1	98.7
2.H.	Industrial processes and product use – Other	CO ₂	12.5	36.9	0.000	0.1	98.7
3.D.2.a.	Indirect N ₂ O emissions from managed soils – Atmospheric deposition	N ₂ O	636.8	741.1	0.000	0.1	98.8
1.B.2.b.iv.	Natural gas – Transmission and storage	CH ₄	2.8	24.3	0.000	0.1	98.8
2.C.1.	Metal industry – Iron and steel production	CO ₂	1,306.7	1,496.4	0.000	0.0	98.9
1.A.3.c.	Railways – Liquid fuels	CO ₂	78.4	108.2	0.000	0.0	98.9
1.A.2.d.	Pulp, paper and print – Liquid fuels	CO ₂	50.1	38.1	0.000	0.0	99.0
2.A.4.	Mineral industry – Other process uses of carbonates	CO ₂	30.5	53.0	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. These uncertainty estimates are for the latest reporting year, and the base year, and the uncertainty in the overall inventory trend over time. Uncertainties for the categories themselves are described in volume 1, 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 table A2.1.1 and table 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 table A2.1.1 and table 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 2023

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO ₂ -e)	2023 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 2023 (%)	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 2023
Energy – Gaseous Fuels	CO ₂	7,014.81	6,209.81	7.5	2.4	7.9	1.2705	0.8672	0.0665	0.1433	0.1604	1.5138	1.5223	1.6143	0.7520
Energy – Liquid Fuels	CO ₂	11,789.48	18,805.62	2.5	0.5	2.5	0.6875	0.8456	0.0809	0.4339	0.0404	1.5204	1.5209	0.4727	0.7150
Energy – Other Fossil Fuels	CO ₂	0.02	78.49	5.0	5.0	7.1	0.0000	0.0099	0.0018	0.0018	0.0091	0.0128	0.0157	0.0000	0.0001
Energy – Solid Fuels	CO ₂	3,211.03	2,240.60	15.2	2.2	15.3	1.1363	0.6113	0.0444	0.0517	0.0964	1.1100	1.1142	1.2912	0.3737
Energy – Fugitive – Oil Exploration	CO ₂	0.00	0.00	2.5	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	2.5	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	2.5	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	7.5	100.0	100.3	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	0.21	7.5	100.0	100.3	0.0000	0.0004	0.0000	0.0000	0.0005	0.0001	0.0005	0.0000	0.0000
Energy – Fugitive – Gas Distribution	CO ₂	1.45	0.26	7.5	100.0	100.3	0.0034	0.0005	0.0000	0.0000	0.0037	0.0001	0.0037	0.0000	0.0000
Energy – Fugitive – Venting and Flaring	CO ₂	229.48	400.38	7.5	2.4	7.9	0.0416	0.0559	0.0024	0.0092	0.0057	0.0976	0.0978	0.0017	0.0031
Energy – Fugitive – Other Forms of Energy Production (Geothermal)	CO ₂	228.58	376.06	5.0	5.0	7.1	0.0373	0.0473	0.0018	0.0087	0.0092	0.0613	0.0620	0.0014	0.0022
IPPU – Cement Production	CO ₂	448.75	378.97	1.0	1.0	1.4	0.0146	0.0095	0.0047	0.0087	0.0047	0.0124	0.0132	0.0002	0.0001
IPPU – Lime Production	CO ₂	82.60	96.23	2.0	2.0	2.8	0.0054	0.0048	0.0003	0.0022	0.0005	0.0063	0.0063	0.0000	0.0000
IPPU – 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
IPPU – Other Uses of Soda Ash	CO ₂	5.87	7.06	3.0	2.0	3.6	0.0005	0.0005	0.0000	0.0002	0.0000	0.0007	0.0007	0.0000	0.0000
IPPU – Other – Other Uses of Limestone	CO ₂	24.63	45.90	3.0	2.0	3.6	0.0020	0.0029	0.0003	0.0011	0.0006	0.0045	0.0045	0.0000	0.0000
IPPU – Ammonia Production	CO ₂	21.68	17.76	2.0	6.0	6.3	0.0032	0.0020	0.0002	0.0004	0.0014	0.0012	0.0018	0.0000	0.0000
IPPU – Calcium Carbide	CO ₂	1.43	1.43	50.0	50.0	70.7	0.0023	0.0018	0.0000	0.0000	0.0005	0.0023	0.0024	0.0000	0.0000
IPPU – Hydrogen Production	CO ₂	152.29	14.38	2.0	6.0	6.3	0.0222	0.0016	0.0042	0.0003	0.0254	0.0009	0.0254	0.0005	0.0000
IPPU – Iron and Steel	CO ₂	1,306.73	1,496.42	5.0	7.0	8.6	0.2593	0.2290	0.0046	0.0345	0.0320	0.2441	0.2462	0.0673	0.0524
IPPU – Aluminium	CO ₂	448.98	542.98	5.0	2.0	5.4	0.0558	0.0520	0.0009	0.0125	0.0018	0.0886	0.0886	0.0031	0.0027

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO ₂ -e)	2023 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 2023 (%)	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 2023
IPPU – 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
IPPU – Lubricant Use	CO ₂	15.20	20.01	20.0	50.0	53.9	0.0189	0.0192	0.0000	0.0005	0.0003	0.0131	0.0131	0.0004	0.0004
IPPU – Paraffin Wax	CO ₂	2.35	2.35	20.0	100.0	102.0	0.0055	0.0043	0.0000	0.0001	0.0016	0.0015	0.0022	0.0000	0.0000
IPPU – Other – Urea Catalyst in Road Transport	CO ₂	0.00	4.63	50.0	10.0	51.0	0.0000	0.0042	0.0001	0.0001	0.0011	0.0075	0.0076	0.0000	0.0000
IPPU – Other	CO ₂	12.48	36.88	80.0	0.0	80.0	0.0230	0.0525	0.0005	0.0009	0.0000	0.0963	0.0963	0.0005	0.0028
Agriculture – Liming	CO ₂	296.48	273.77	3.4	50.0	50.1	0.3428	0.2441	0.0026	0.0063	0.1278	0.0304	0.1313	0.1175	0.0596
Agriculture – Urea Application	CO ₂	39.19	425.65	10.0	50.0	51.0	0.0461	0.3861	0.0086	0.0098	0.4324	0.1389	0.4541	0.0021	0.1490
LULUCF – Forest Land	CO ₂	-23,526.24	-18,488.31	0.0	62.3	62.3	-33.8291	-20.4969	0.2790	0.4265	17.3865	0.0000	17.3865	1,144.4092	420.1230
LULUCF – Cropland	CO ₂	471.54	722.49	0.0	57.3	57.3	0.6229	0.7359	0.0026	0.0167	0.1465	0.0000	0.1465	0.3880	0.5415
LULUCF – Grassland	CO ₂	703.30	2,854.11	0.0	40.9	40.9	0.6640	2.0777	0.0448	0.0658	1.8332	0.0000	1.8332	0.4410	4.3169
LULUCF – Wetlands	CO ₂	-8.29	7.34	0.0	127.1	127.1	-0.0243	0.0166	0.0004	0.0002	0.0530	0.0000	0.0530	0.0006	0.0003
LULUCF – Settlements	CO ₂	78.51	119.26	0.0	65.5	65.5	0.1187	0.1390	0.0004	0.0028	0.0263	0.0000	0.0263	0.0141	0.0193
LULUCF – Other Land	CO ₂	14.67	82.42	0.0	85.5	85.5	0.0289	0.1253	0.0015	0.0019	0.1250	0.0000	0.1250	0.0008	0.0157
LULUCF – Harvested Wood Products	CO ₂	-2,437.78	-5,808.29	0.0	68.2	68.2	-3.8378	-7.0501	0.0611	0.1340	4.1687	0.0000	4.1687	14.7291	49.7035
Waste – Incineration and Open Burning of Waste	CO ₂	153.26	81.48	50.0	40.0	64.0	0.2264	0.0928	0.0027	0.0019	0.1082	0.1329	0.1714	0.0513	0.0086
Tokelau Energy Industries – Sectoral Approach – Liquid	CO ₂	0.23	0.77	10.0	7.0	12.2	0.0001	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	1.42	50.0	1.5	50.0	0.0010	0.0013	0.0000	0.0000	0.0000	0.0023	0.0023	0.0000	0.0000
Tokelau Other/Residential – Sectoral Approach – Liquid	CO ₂	0.12	0.06	20.0	7.0	21.2	0.0001	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	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000
Energy – Gaseous Fuels	CH ₄	77.75	73.25	7.5	50.0	50.6	0.0907	0.0659	0.0006	0.0017	0.0318	0.0179	0.0365	0.0082	0.0043
Energy – Liquid Fuels	CH ₄	10.14	4.41	2.5	50.0	50.1	0.0117	0.0039	0.0002	0.0001	0.0101	0.0004	0.0101	0.0001	0.0000
Energy – Other Fossil Fuels	CH ₄	98.03	37.65	5.0	50.0	50.2	0.1136	0.0337	0.0021	0.0009	0.1032	0.0061	0.1034	0.0129	0.0011
Energy – Solid Fuels	CH ₄	0.01	0.07	15.2	50.0	52.3	0.0000	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000
Energy – Biomass	CH ₄	40.76	18.54	50.0	50.0	70.7	0.0665	0.0233	0.0008	0.0004	0.0396	0.0302	0.0498	0.0044	0.0005

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO ₂ -e)	2023 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 2023 (%)	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 2023
Energy – Fugitive – Coal Handling	CH ₄	367.40	63.41	15.2	50.0	52.3	0.4429	0.0589	0.0095	0.0015	0.4765	0.0314	0.4775	0.1962	0.0035
Energy – Fugitive – Oil Exploration	CH ₄	0.00	0.00	2.5	50.0	50.1	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	0.03	2.5	50.0	50.1	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	0.88	2.5	50.0	50.1	0.0022	0.0008	0.0000	0.0000	0.0018	0.0001	0.0018	0.0000	0.0000
Energy – Fugitive – Oil Refining	CH ₄	3.06	0.00	2.5	50.0	50.1	0.0035	0.0000	0.0001	0.0000	0.0046	0.0000	0.0046	0.0000	0.0000
Energy – Fugitive – Gas Production	CH ₄	160.67	142.26	7.5	50.0	50.6	0.1874	0.1279	0.0015	0.0033	0.0763	0.0347	0.0838	0.0351	0.0164
Energy – Fugitive – Gas Transmission and Storage	CH ₄	2.77	24.28	7.5	100.0	100.3	0.0064	0.0433	0.0005	0.0006	0.0477	0.0059	0.0481	0.0000	0.0019
Energy – Fugitive – Gas Distribution	CH ₄	310.78	29.89	7.5	100.0	100.3	0.7190	0.0533	0.0086	0.0007	0.8609	0.0073	0.8610	0.5170	0.0028
Energy – Fugitive – Venting and Flaring	CH ₄	194.53	34.98	7.5	50.0	50.6	0.2269	0.0315	0.0050	0.0008	0.2507	0.0085	0.2508	0.0515	0.0010
Energy – Fugitive – Other Forms of Energy Production (Geothermal)	CH ₄	61.37	100.98	5.0	5.0	7.1	0.0100	0.0127	0.0005	0.0023	0.0025	0.0165	0.0167	0.0001	0.0002
IPPU – Methanol	CH ₄	30.91	89.36	2.0	80.0	80.0	0.0571	0.1272	0.0011	0.0021	0.0909	0.0058	0.0911	0.0033	0.0162
Agriculture – Enteric Fermentation	CH ₄	31,034.93	31,661.72	3.9	15.5	16.0	11.4560	9.0109	0.1968	0.7305	3.0538	4.0288	5.0554	131.2402	81.1970
Agriculture – Manure Management	CH ₄	824.79	1,772.63	5.0	20.0	20.6	0.3923	0.6500	0.0162	0.0409	0.3242	0.2892	0.4345	0.1539	0.4225
Agriculture – Burning of Residues	CH ₄	25.34	15.41	6.0	20.0	20.9	0.0122	0.0057	0.0004	0.0004	0.0081	0.0030	0.0086	0.0001	0.0000
LULUCF – CH ₄ emissions associated with Biomass Burning (CO ₂ -e)	CH ₄	77.62	45.81	30.0	41.7	51.4	0.0920	0.0419	0.0013	0.0011	0.0528	0.0448	0.0693	0.0085	0.0018
Waste – Solid Waste Disposal	CH ₄	2,630.43	2,256.78	79.9	40.0	89.4	5.4227	3.5870	0.0266	0.0521	1.0652	5.8834	5.9790	29.4053	12.8663
Waste – Wastewater Treatment and Discharge	CH ₄	250.41	290.75	10.0	40.0	41.2	0.2382	0.2132	0.0008	0.0067	0.0314	0.0949	0.0999	0.0567	0.0455
Waste – Biological Treatment of Solid Waste	CH ₄	3.07	52.31	94.1	100.0	137.3	0.0097	0.1278	0.0011	0.0012	0.1115	0.1607	0.1956	0.0001	0.0163
Waste – Incineration and Open Burning of Waste	CH ₄	139.99	80.37	50.0	100.0	111.8	0.3611	0.1598	0.0023	0.0019	0.2335	0.1311	0.2678	0.1304	0.0255

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO ₂ -e)	2023 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 2023 (%)	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 2023
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	0.0006	0.0007	0.0000	0.0000
Tokelau Waste – Solid Waste Disposal	CH ₄	0.44	0.35	140.0	40.0	145.6	0.0015	0.0009	0.0000	0.0000	0.0002	0.0016	0.0016	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	0.0003	0.0002	0.0000	0.0000	0.0001	0.0001	0.0002	0.0000	0.0000
Energy – Gaseous Fuels	N ₂ O	36.52	36.67	7.5	50.0	50.6	0.0426	0.0330	0.0002	0.0008	0.0123	0.0089	0.0152	0.0018	0.0011
Energy – Liquid Fuels	N ₂ O	4.92	2.75	2.5	50.0	50.1	0.0057	0.0024	0.0001	0.0001	0.0042	0.0002	0.0042	0.0000	0.0000
Energy – Other Fossil Fuels	N ₂ O	140.46	159.64	5.0	50.0	50.2	0.1628	0.1427	0.0005	0.0037	0.0260	0.0260	0.0368	0.0265	0.0204
Energy – Solid Fuels	N ₂ O	0.18	0.46	15.2	50.0	52.3	0.0002	0.0004	0.0000	0.0000	0.0003	0.0002	0.0003	0.0000	0.0000
Energy – Biomass	N ₂ O	13.33	9.19	50.0	50.0	70.7	0.0217	0.0116	0.0002	0.0002	0.0093	0.0150	0.0177	0.0005	0.0001
Energy – Fugitive – Venting and Flaring	N ₂ O	0.05	0.02	7.5	100.0	100.3	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000
IPPU – N ₂ O from Product Uses	N ₂ O	88.76	112.49	15.0	0.0	15.0	0.0307	0.0300	0.0001	0.0026	0.0000	0.0551	0.0551	0.0009	0.0009
Agriculture – Agricultural Soils	N ₂ O	4,655.12	6,372.43	13.8	54.2	55.9	6.0048	6.3376	0.0077	0.1470	0.4178	2.8769	2.9071	36.0579	40.1656
Agriculture – Manure Management	N ₂ O	35.01	88.84	5.0	100.0	100.1	0.0809	0.1582	0.0010	0.0020	0.1002	0.0145	0.1013	0.0065	0.0250
Agriculture – Burning of Residues	N ₂ O	4.24	2.54	6.0	20.0	20.9	0.0020	0.0009	0.0001	0.0001	0.0014	0.0005	0.0015	0.0000	0.0000
LULUCF – Direct and Indirect N ₂ O emissions (CO ₂ -e)	N ₂ O	269.24	242.80	0.0	56.0	56.0	0.3482	0.2421	0.0025	0.0056	0.1376	0.0000	0.1376	0.1212	0.0586

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO ₂ -e)	2023 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 2023 (%)	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 2023
LULUCF – N ₂ O emissions associated with Biomass Burning (CO ₂ -e)	N ₂ O	23.36	25.24	30.0	41.7	51.4	0.0277	0.0231	0.0001	0.0006	0.0049	0.0247	0.0252	0.0008	0.0005
Waste – Wastewater Treatment and Discharge	N ₂ O	72.93	110.52	10.0	90.0	90.6	0.1524	0.1780	0.0004	0.0025	0.0331	0.0361	0.0489	0.0232	0.0317
Waste – Biological Treatment of Solid Waste	N ₂ O	1.74	29.33	100.0	150.0	180.3	0.0072	0.0941	0.0006	0.0007	0.0937	0.0957	0.1339	0.0001	0.0088
Waste – Incineration and Open Burning of Waste	N ₂ O	25.76	15.08	50.0	100.0	111.8	0.0664	0.0300	0.0004	0.0003	0.0423	0.0246	0.0489	0.0044	0.0009
Tokelau Energy industries – Sectoral Approach – Liquid	N ₂ O	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 ₂ O	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 ₂ O	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 ₂ O	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 ₂ O	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 ₂ O	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
IPPU – Refrigeration and Air Conditioning	HFCs	0.00	1,011.36	24.0	0.0	24.0	0.0000	0.4317	0.0233	0.0233	0.0000	0.7919	0.7919	0.0000	0.1864
IPPU – Foam Blowing Agents	HFCs	0.00	5.69	12.0	50.0	51.4	0.0000	0.0052	0.0001	0.0001	0.0066	0.0022	0.0069	0.0000	0.0000
IPPU – Fire Protection	HFCs	0.00	2.21	30.0	30.0	42.4	0.0000	0.0017	0.0001	0.0001	0.0015	0.0022	0.0026	0.0000	0.0000
IPPU – Aerosols	HFCs	0.00	67.87	25.0	10.0	26.9	0.0000	0.0325	0.0016	0.0016	0.0157	0.0554	0.0575	0.0000	0.0011
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
IPPU – Aluminium	PFCs	818.01	60.90	5.0	30.0	30.4	0.5740	0.0329	0.0231	0.0014	0.6920	0.0099	0.6921	0.3294	0.0011
IPPU – 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
IPPU – 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
IPPU – Magnesium Production	SF ₆	2.82	0.00	100.0	30.0	104.4	0.0068	0.0000	0.0001	0.0000	0.0025	0.0000	0.0025	0.0000	0.0000

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO ₂ -e)	2023 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 2023 (%)	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 2023
IPPU – Electrical Equipment	SF ₆	14.95	13.81	20.0	30.0	36.1	0.0124	0.0089	0.0001	0.0003	0.0039	0.0090	0.0098	0.0002	0.0001
IPPU – Other Product Use	SF ₆	2.82	2.82	80.0	0.0	80.0	0.0052	0.0040	0.0000	0.0001	0.0000	0.0074	0.0074	0.0000	0.0000
		Total emissions/ removals in 1990	Total emissions/ removals in current year										Uncertainty in the trend	Uncertainty in the base year	Uncertainty in the final year
		43,344.8	56,219.2										20.0 %	36.9 %	24.7 %

Table A2.1.2 Uncertainty calculation of the gross emissions and removals for New Zealand in 2023

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO ₂ -e)	2023 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 2023 (%)	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 2023
Energy – Gaseous Fuels	CO ₂	7,014.81	6,209.81	7.5	2.4	7.9	0.8137	0.6380	0.0252	0.0918	0.0609	0.9695	0.9714	0.6621	0.4070
Energy – Liquid Fuels	CO ₂	11,789.48	18,805.62	2.5	0.5	2.5	0.4403	0.6221	0.0810	0.2779	0.0405	0.9737	0.9746	0.1939	0.3870
Energy – Other Fossil Fuels	CO ₂	0.02	78.49	5.0	5.0	7.1	0.0000	0.0073	0.0012	0.0012	0.0058	0.0082	0.0100	0.0000	0.0001
Energy – Solid Fuels	CO ₂	3,211.03	2,240.60	15.2	2.2	15.3	0.7278	0.4498	0.0205	0.0331	0.0445	0.7109	0.7123	0.5296	0.2023
Energy – Fugitive – Oil Exploration	CO ₂	0.00	0.00	2.5	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	2.5	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	2.5	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	7.5	100.0	100.3	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	0.21	7.5	100.0	100.3	0.0000	0.0003	0.0000	0.0000	0.0003	0.0000	0.0003	0.0000	0.0000
Energy – Fugitive – Gas Distribution	CO ₂	1.45	0.26	7.5	100.0	100.3	0.0021	0.0003	0.0000	0.0000	0.0020	0.0000	0.0020	0.0000	0.0000
Energy – Fugitive – Venting and Flaring	CO ₂	229.48	400.38	7.5	2.4	7.9	0.0266	0.0411	0.0021	0.0059	0.0050	0.0625	0.0627	0.0007	0.0017

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO ₂ -e)	2023 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 2023 (%)	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 2023
Energy – Fugitive – Other Forms of Energy Production (Geothermal)	CO ₂	228.58	376.06	5.0	5.0	7.1	0.0239	0.0348	0.0017	0.0056	0.0087	0.0393	0.0402	0.0006	0.0012
IPPU – Cement Production	CO ₂	448.75	378.97	1.0	1.0	1.4	0.0094	0.0070	0.0019	0.0056	0.0019	0.0079	0.0081	0.0001	0.0000
IPPU – Lime Production	CO ₂	82.60	96.23	2.0	2.0	2.8	0.0035	0.0036	0.0000	0.0014	0.0001	0.0040	0.0040	0.0000	0.0000
IPPU – 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
IPPU – Other Uses of Soda Ash	CO ₂	5.87	7.06	3.0	2.0	3.6	0.0003	0.0003	0.0000	0.0001	0.0000	0.0004	0.0004	0.0000	0.0000
IPPU – Other – Other Uses of Limestone	CO ₂	24.63	45.90	3.0	2.0	3.6	0.0013	0.0022	0.0003	0.0007	0.0005	0.0029	0.0029	0.0000	0.0000
IPPU – Ammonia Production	CO ₂	21.68	17.76	2.0	6.0	6.3	0.0020	0.0015	0.0001	0.0003	0.0006	0.0007	0.0010	0.0000	0.0000
IPPU – 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
IPPU – Hydrogen Production	CO ₂	152.29	14.38	2.0	6.0	6.3	0.0142	0.0012	0.0023	0.0002	0.0140	0.0006	0.0140	0.0002	0.0000
IPPU – Iron and Steel	CO ₂	1,306.73	1,496.42	5.0	7.0	8.6	0.1661	0.1685	0.0003	0.0221	0.0022	0.1563	0.1564	0.0276	0.0284
IPPU – Aluminium	CO ₂	448.98	542.98	5.0	2.0	5.4	0.0357	0.0383	0.0005	0.0080	0.0011	0.0567	0.0567	0.0013	0.0015
IPPU – Secondary Lead Production	CO ₂	1.80	0.00	50.0	50.0	70.7	0.0019	0.0000	0.0000	0.0000	0.0015	0.0000	0.0015	0.0000	0.0000
IPPU – Lubricant Use	CO ₂	15.20	20.01	20.0	50.0	53.9	0.0121	0.0141	0.0000	0.0003	0.0021	0.0084	0.0086	0.0001	0.0002
IPPU – Paraffin Wax	CO ₂	2.35	2.35	20.0	100.0	102.0	0.0035	0.0031	0.0000	0.0000	0.0004	0.0010	0.0011	0.0000	0.0000
IPPU – Other – Urea Catalyst in Road Transport	CO ₂	0.00	4.63	50.0	10.0	51.0	0.0000	0.0031	0.0001	0.0001	0.0007	0.0048	0.0049	0.0000	0.0000
IPPU – Other	CO ₂	12.48	36.88	80.0	0.0	80.0	0.0148	0.0386	0.0003	0.0005	0.0000	0.0617	0.0617	0.0002	0.0015
Agriculture – Liming	CO ₂	296.48	273.77	3.4	50.0	50.1	0.2195	0.1795	0.0009	0.0040	0.0451	0.0195	0.0491	0.0482	0.0322
Agriculture – Urea Application	CO ₂	39.19	425.65	10.0	50.0	51.0	0.0295	0.2840	0.0056	0.0063	0.2818	0.0889	0.2955	0.0009	0.0807
Waste – Incineration and Open Burning of Waste	CO ₂	153.26	81.48	50.0	40.0	64.0	0.1450	0.0683	0.0014	0.0012	0.0541	0.0851	0.1009	0.0210	0.0047
Tokelau Energy Industries – Sectoral Approach – Liquid	CO ₂	0.23	0.77	10.0	7.0	12.2	0.0000	0.0001	0.0000	0.0000	0.0001	0.0002	0.0002	0.0000	0.0000
Tokelau Gas Diesel Oil – Sectoral Approach – Liquid	CO ₂	0.90	1.42	50.0	1.5	50.0	0.0007	0.0009	0.0000	0.0000	0.0000	0.0015	0.0015	0.0000	0.0000

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO ₂ -e)	2023 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 2023 (%)	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 2023
Tokelau Other/ Residential – Sectoral Approach – Liquid	CO ₂	0.12	0.06	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	77.75	73.25	7.5	50.0	50.6	0.0581	0.0485	0.0002	0.0011	0.0107	0.0114	0.0157	0.0034	0.0023
Energy – Liquid Fuels	CH ₄	10.14	4.41	2.5	50.0	50.1	0.0075	0.0029	0.0001	0.0001	0.0052	0.0002	0.0052	0.0001	0.0000
Energy – Other Fossil Fuels	CH ₄	98.03	37.65	5.0	50.0	50.2	0.0728	0.0248	0.0011	0.0006	0.0540	0.0039	0.0541	0.0053	0.0006
Energy – Solid Fuels	CH ₄	0.01	0.07	15.2	50.0	52.3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
Energy – Biomass	CH ₄	40.76	18.54	50.0	50.0	70.7	0.0426	0.0172	0.0004	0.0003	0.0203	0.0194	0.0281	0.0018	0.0003
Energy – Fugitive – Coal Handling	CH ₄	367.40	63.41	15.2	50.0	52.3	0.2837	0.0434	0.0052	0.0009	0.2596	0.0201	0.2604	0.0805	0.0019
Energy – Fugitive – Oil Exploration	CH ₄	0.00	0.00	2.5	50.0	50.1	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	0.03	2.5	50.0	50.1	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Energy – Fugitive – Oil Transport	CH ₄	1.88	0.88	2.5	50.0	50.1	0.0014	0.0006	0.0000	0.0000	0.0009	0.0000	0.0009	0.0000	0.0000
Energy – Fugitive – Oil Refining	CH ₄	3.06	0.00	2.5	50.0	50.1	0.0023	0.0000	0.0001	0.0000	0.0025	0.0000	0.0025	0.0000	0.0000
Energy – Fugitive – Gas Production	CH ₄	160.67	142.26	7.5	50.0	50.6	0.1200	0.0941	0.0006	0.0021	0.0289	0.0222	0.0365	0.0144	0.0089
Energy – Fugitive – Gas Transmission and Storage	CH ₄	2.77	24.28	7.5	100.0	100.3	0.0041	0.0319	0.0003	0.0004	0.0313	0.0038	0.0315	0.0000	0.0010
Energy – Fugitive – Gas Distribution	CH ₄	310.78	29.89	7.5	100.0	100.3	0.4605	0.0392	0.0047	0.0004	0.4743	0.0047	0.4743	0.2120	0.0015
Energy – Fugitive – Venting and Flaring	CH ₄	194.53	34.98	7.5	50.0	50.6	0.1453	0.0231	0.0027	0.0005	0.1364	0.0055	0.1365	0.0211	0.0005
Energy – Fugitive – Other Forms of Energy Production (Geothermal)	CH ₄	61.37	100.98	5.0	5.0	7.1	0.0064	0.0093	0.0005	0.0015	0.0023	0.0106	0.0108	0.0000	0.0001
IPPU – Methanol	CH ₄	30.91	89.36	2.0	80.0	80.0	0.0366	0.0936	0.0008	0.0013	0.0644	0.0037	0.0645	0.0013	0.0088
Agriculture – Enteric Fermentation	CH ₄	31,034.93	31,661.72	3.9	15.5	16.0	7.3370	6.6293	0.0497	0.4678	0.7714	2.5802	2.6931	53.8313	43.9478
Agriculture – Manure Management	CH ₄	824.79	1,772.63	5.0	20.0	20.6	0.2512	0.4782	0.0124	0.0262	0.2486	0.1852	0.3100	0.0631	0.2287

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO ₂ -e)	2023 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 2023 (%)	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 2023
Agriculture – Burning of Residues	CH ₄	25.34	15.41	6.0	20.0	20.9	0.0078	0.0042	0.0002	0.0002	0.0039	0.0019	0.0044	0.0001	0.0000
Waste – Solid Waste Disposal	CH ₄	2,630.43	2,256.78	79.9	40.0	89.4	3.4729	2.6389	0.0105	0.0333	0.4214	3.7680	3.7915	12.0613	6.9639
Waste – Wastewater Treatment and Discharge	CH ₄	250.41	290.75	10.0	40.0	41.2	0.1526	0.1569	0.0001	0.0043	0.0047	0.0608	0.0609	0.0233	0.0246
Waste – Biological Treatment of Solid Waste	CH ₄	3.07	52.31	94.1	100.0	137.3	0.0062	0.0940	0.0007	0.0008	0.0722	0.1029	0.1257	0.0000	0.0088
Waste – Incineration and Open Burning of Waste	CH ₄	139.99	80.37	50.0	100.0	111.8	0.2313	0.1176	0.0011	0.0012	0.1148	0.0840	0.1422	0.0535	0.0138
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	0.0000	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	0.0007	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 ₂ O	36.52	36.67	7.5	50.0	50.6	0.0273	0.0243	0.0001	0.0005	0.0034	0.0057	0.0066	0.0007	0.0006
Energy – Liquid Fuels	N ₂ O	4.92	2.75	2.5	50.0	50.1	0.0036	0.0018	0.0000	0.0000	0.0021	0.0001	0.0021	0.0000	0.0000
Energy – Other Fossil Fuels	N ₂ O	140.46	159.64	5.0	50.0	50.2	0.1043	0.1050	0.0000	0.0024	0.0008	0.0167	0.0167	0.0109	0.0110
Energy – Solid Fuels	N ₂ O	0.18	0.46	15.2	50.0	52.3	0.0001	0.0003	0.0000	0.0000	0.0002	0.0001	0.0002	0.0000	0.0000
Energy – Biomass	N ₂ O	13.33	9.19	50.0	50.0	70.7	0.0139	0.0085	0.0001	0.0001	0.0043	0.0096	0.0105	0.0002	0.0001

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO ₂ -e)	2023 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 2023 (%)	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 2023
Energy – Fugitive – Venting and Flaring	N ₂ O	0.05	0.02	7.5	100.0	100.3	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000
IPPU – N ₂ O from Product Uses	N ₂ O	88.76	112.49	15.0	0.0	15.0	0.0197	0.0221	0.0002	0.0017	0.0000	0.0353	0.0353	0.0004	0.0005
Agriculture – Agricultural Soils	N ₂ O	4,655.12	6,372.43	13.8	54.2	55.9	3.8458	4.6626	0.0165	0.0942	0.8929	1.8425	2.0475	14.7900	21.7396
Agriculture – Manure Management	N ₂ O	35.01	88.84	5.0	100.0	100.1	0.0518	0.1164	0.0007	0.0013	0.0729	0.0093	0.0735	0.0027	0.0135
Agriculture – Burning of Residues	N ₂ O	4.24	2.54	6.0	20.0	20.9	0.0013	0.0007	0.0000	0.0000	0.0007	0.0003	0.0007	0.0000	0.0000
Waste – Wastewater Treatment and Discharge	N ₂ O	72.93	110.52	10.0	90.0	90.6	0.0976	0.1310	0.0004	0.0016	0.0375	0.0231	0.0440	0.0095	0.0172
Waste – Biological Treatment of Solid Waste	N ₂ O	1.74	29.33	100.0	150.0	180.3	0.0046	0.0692	0.0004	0.0004	0.0607	0.0613	0.0862	0.0000	0.0048
Waste – Incineration and Open Burning of Waste	N ₂ O	25.76	15.08	50.0	100.0	111.8	0.0426	0.0221	0.0002	0.0002	0.0207	0.0158	0.0260	0.0018	0.0005
Tokelau Energy industries – Sectoral Approach – Liquid	N ₂ O	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 ₂ O	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 ₂ O	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 ₂ O	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 ₂ O	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 ₂ O	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
IPPU – Refrigeration and Air Conditioning	HFCs	0.00	1,011.36	24.0	0.0	24.0	0.0000	0.3176	0.0149	0.0149	0.0000	0.5072	0.5072	0.0000	0.1009
IPPU – Foam Blowing Agents	HFCs	0.00	5.69	12.0	50.0	51.4	0.0000	0.0038	0.0001	0.0001	0.0042	0.0014	0.0044	0.0000	0.0000
IPPU – Fire Protection	HFCs	0.00	2.21	30.0	30.0	42.4	0.0000	0.0012	0.0000	0.0000	0.0010	0.0014	0.0017	0.0000	0.0000

IPCC source category	Gas	1990 emissions or absolute value of removals (kt CO ₂ -e)	2023 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 2023 (%)	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 2023	
IPPU – Aerosols	HFCs	0.00	67.87	25.0	10.0	26.9	0.0000	0.0239	0.0010	0.0010	0.0100	0.0355	0.0368	0.0000	0.0006	
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	
IPPU – Aluminium	PFCs	818.01	60.90	5.0	30.0	30.4	0.3676	0.0242	0.0127	0.0009	0.3824	0.0064	0.3824	0.1351	0.0006	
IPPU – 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	
IPPU – 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	
IPPU – Magnesium Production	SF ₆	2.82	0.00	100.0	30.0	104.4	0.0044	0.0000	0.0000	0.0000	0.0014	0.0000	0.0014	0.0000	0.0000	
IPPU – Electrical Equipment	SF ₆	14.95	13.81	20.0	30.0	36.1	0.0080	0.0065	0.0000	0.0002	0.0014	0.0058	0.0059	0.0001	0.0000	
IPPU – Other Product Use	SF ₆	2.82	2.82	80.0	0.0	80.0	0.0033	0.0030	0.0000	0.0000	0.0000	0.0047	0.0047	0.0000	0.0000	
		Total emissions/ removals in 1990	Total emissions/ removals in current year											Uncertainty in the trend	Uncertainty in the base year	Uncertainty in the final year
		67,678.9	76,416.3											5.4 %	9.1 %	8.6 %

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 (CO₂) 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 A5.4). 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 CO₂ 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 (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 3.1.5, some of the coal production activity data in the reference approach are allocated to steel production. The Industrial Processes and Product Use sector accounts for the CO₂ emissions from this coal in the sectoral approach, as recommended by the IPCC Guidelines (IPCC, 2006); therefore, they are not included in the common reporting table 1.AA *Fuel combustion* – sectoral approach.

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

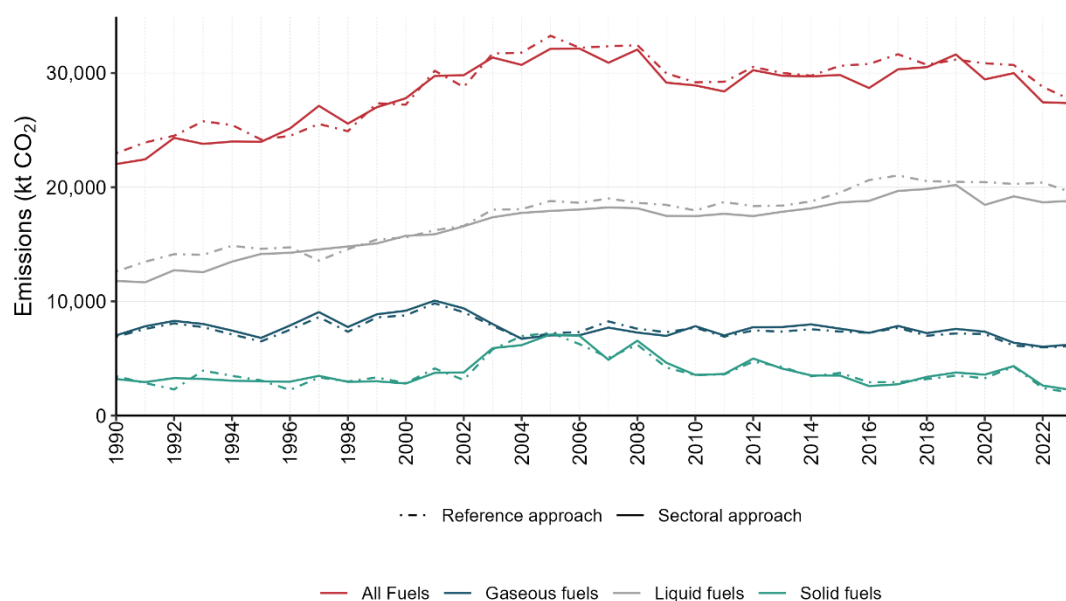
A3.2 Comparison of the IPCC reference approach with the New Zealand sectoral methodology

For 2023, CO₂ emissions estimated with the sectoral approach were 8.5 per cent higher than those estimated with the reference approach. Figure A3.2.1 shows the results for the two approaches for the period 1990 to 2023.

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, 2024) 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 the 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



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. 2024. *Energy in New Zealand 2024*. 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

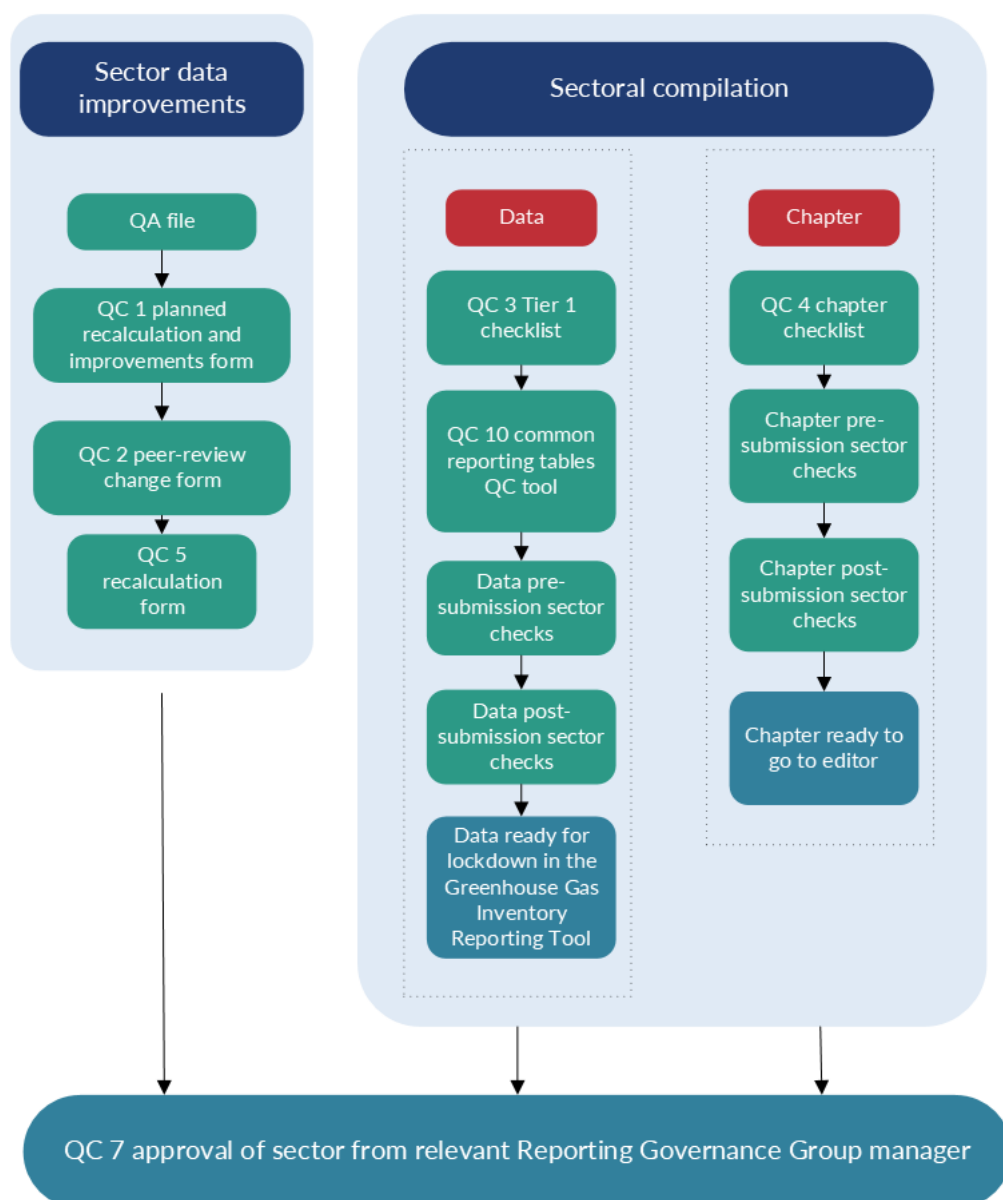
Quality-assurance and quality-control (QA/QC) processes have a significant role in the preparation of *New Zealand's Greenhouse Gas Inventory* (the Inventory), to ensure the core principles of transparency, accuracy, completeness, comparability and consistency are achieved. Table A4.1.1 describes the 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 national 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.

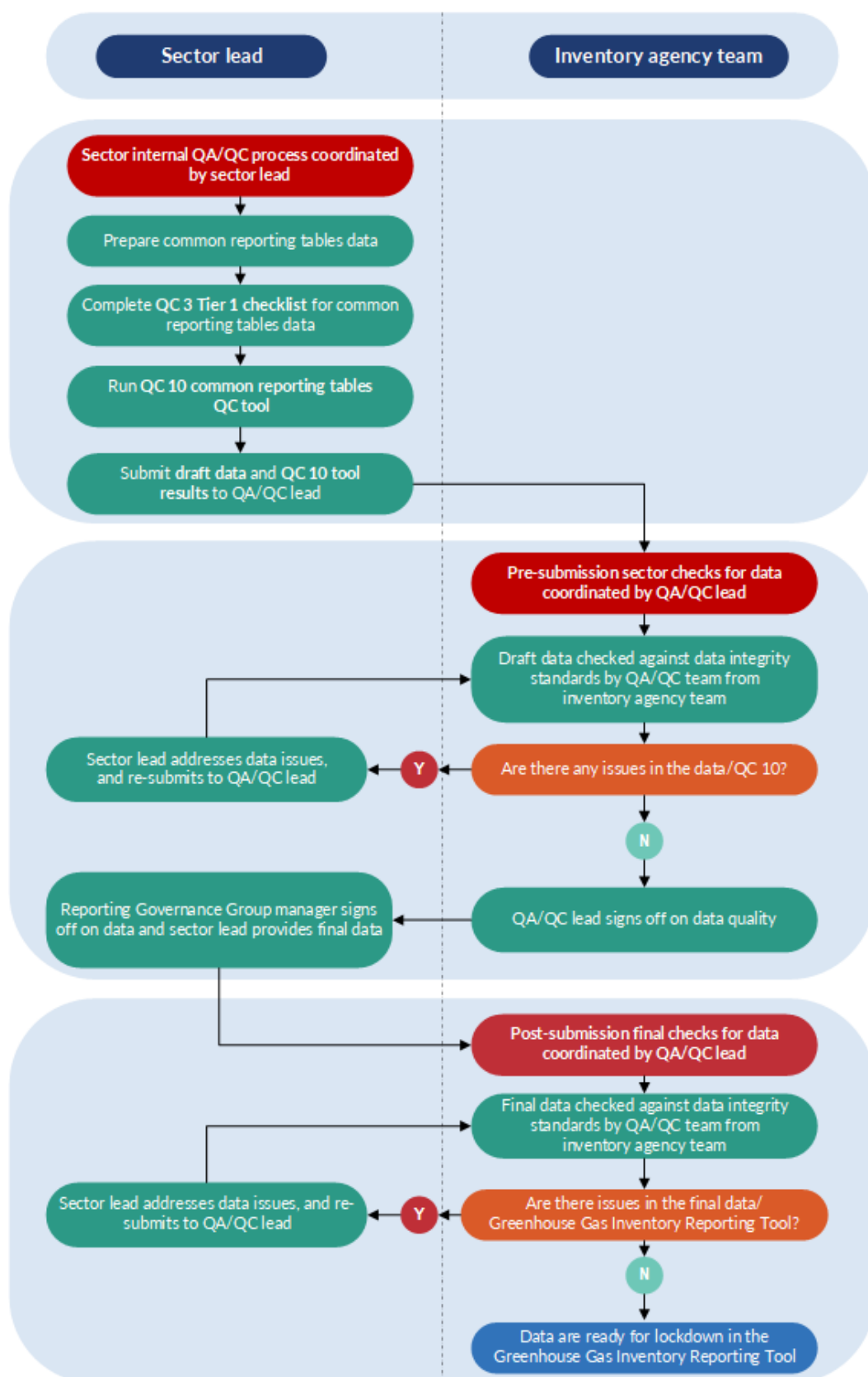
Figure A4.1.1 presents an overview of QA/QC processes and how they align with the sector data improvements and sectoral compilation of data and chapters. Figures A4.1.2 and A4.1.3 show process diagrams for pre-submission and post-submission sector checks for data and chapters, while figure A4.1.4 lists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



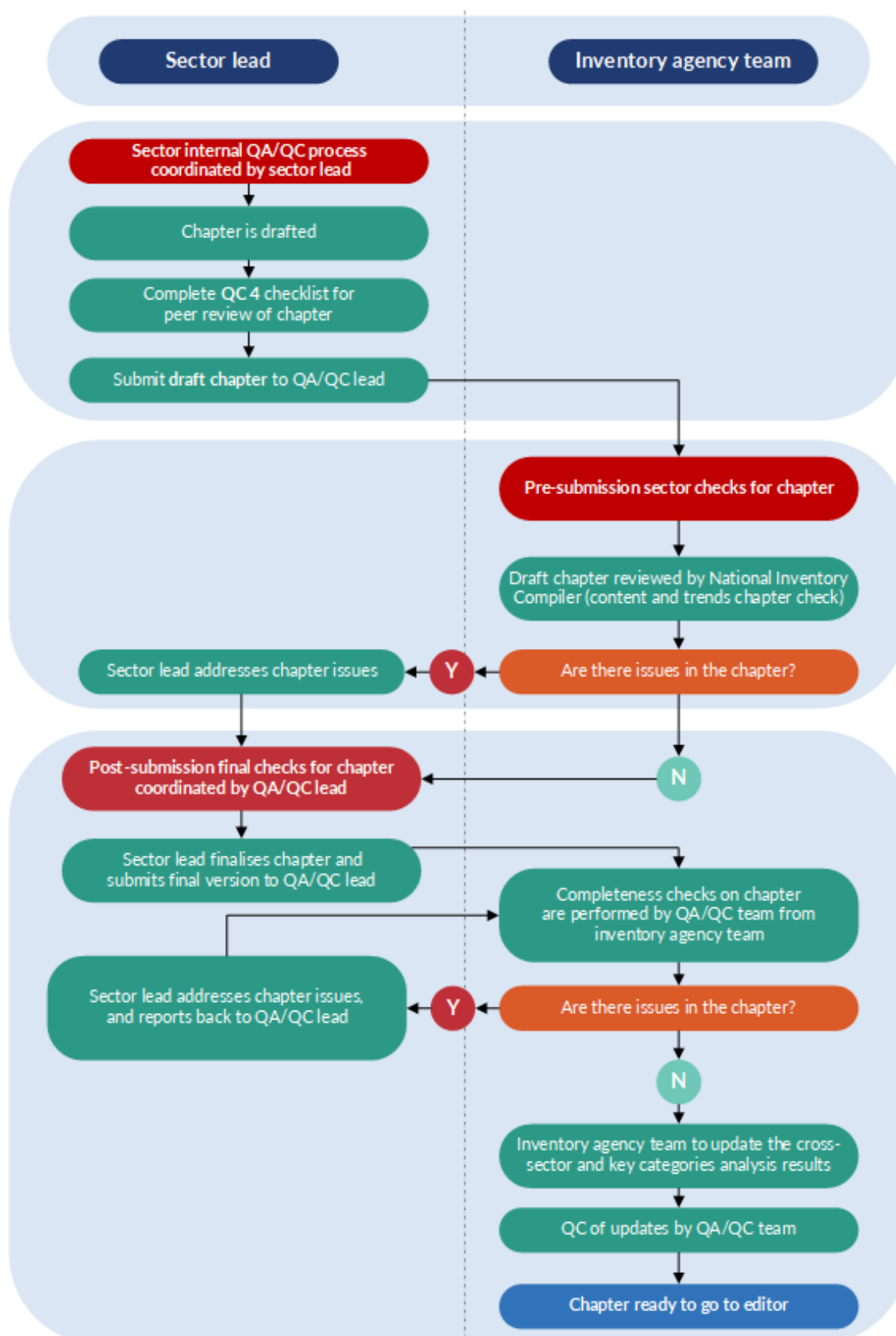
Note: See table A4.1.1: Quality-assurance and quality-control (QA/QC) processes used in preparation of the inventory sectors.

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



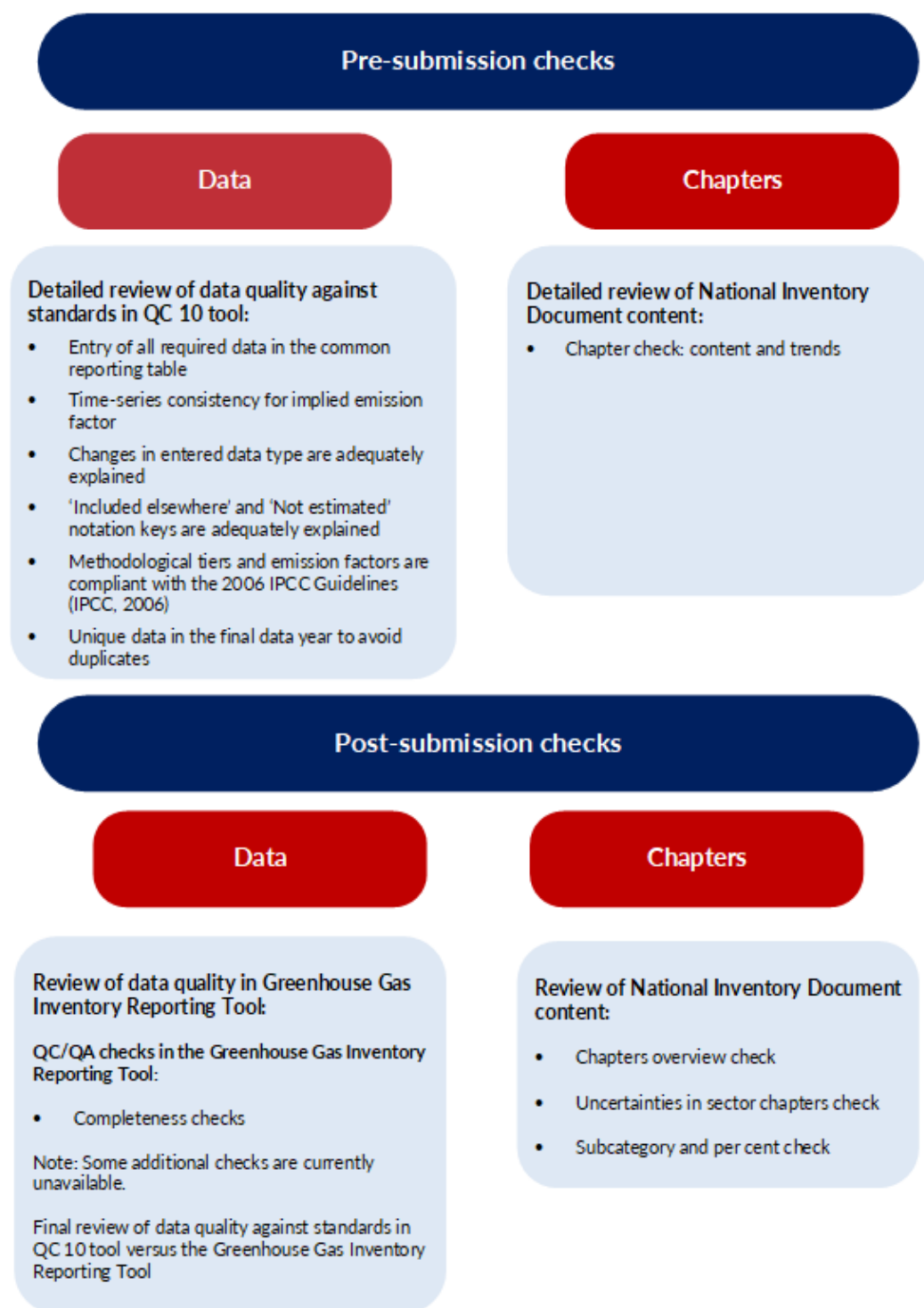
Note: See table A4.1.1: Quality-assurance and quality-control (QA/QC) processes used in preparation of the inventory sectors.

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



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: 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 Census 2022 and Agricultural Production Survey 2023

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 (2023 details: www.stats.govt.nz/information-releases/agricultural-production-statistics-year-to-june-2023-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 methodology to the APC but targets about half of the businesses involved in agriculture or forestry production. New Zealand's Greenhouse Gas Inventory (the Inventory) is compiled with data from the APC and APS.

The 2023 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 2023). The response rate, or the estimated proportion of eligible businesses that responded to the 2022 APC, was 73 per cent. The response rate for the 2023 APS was 70 per cent.

The imputation levels of the 2022 APC and 2023 APS 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 Census in 2022 and the Agricultural Production Survey in 2023

Agricultural Production Census and Agricultural Production Survey category	Proportion of total estimate imputed (%)		Relative sampling errors at 95% confidence interval (%)	
	2022	2023	2022	2023
Ewe hoggets put to ram	28	28	NA	5
Breeding ewes, two tooth and over	30	30	NA	3
Total number of sheep	30	30	NA	3
Lambs born to ewe hoggets	29	30	NA	5
Lambs born to ewes	30	30	NA	3
Total number of lambs	30	30	NA	3
Calves born alive to dairy heifers and/or cows	29	29	NA	3
Dairy cows and heifers, in milk or calf	34	35	NA	5
Total number of dairy cattle	33	34	NA	4
Calves born alive to beef heifers and/or cows	29	29	NA	3
Beef cows and heifers (in calf) one to two years	27	27	NA	7
Beef cows and heifers (in calf) two years and over	27	28	NA	3
Total number of beef cattle	28	28	NA	3
Female deer mated	27	27	NA	7
Total number of deer	29	29	NA	7
Fawns born on farm and alive at four months	28	28	NA	7
Total pigs	5	6	NA	6
Area of wheat harvested	35	34	NA	12
Area of barley harvested	34	33	NA	11
Area of oat grain harvested	38	37	NA	26
Area of maize grain harvested	23	22	NA	10

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 A5.1.3 shows line codes used for major livestock subcategories (dairy cattle, beef cattle, sheep and deer) in New Zealand's Tier 2 livestock modelling.

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

Livestock category	Subcategory
	Manawatu–Whanganui
	Wellington
	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	Velvet hinds less than one year
	Velvet hinds one to two years
	Velvet hinds mature
	Velvet stags less than one year
	Velvet stags one to two years
	Velvet stags two to three years
	Velvet stags mature
	Venison hinds less than one year
	Venison hinds breeding one to two years
	Venison hinds mature
	Venison hinds non-breeding one to two years
	Venison stags less than one year
	Venison stags one to two years
	Venison stags two to three years
	Venison stags mature

Table A5.1.3 Agricultural Production Survey and Agricultural Production Census line codes used for major livestock subcategories (dairy cattle, beef cattle, sheep and deer) in New Zealand's Tier 2 livestock modelling

Livestock category	Description	Line code
Dairy cattle	Dairy cows and heifers in milk or calf two years old and over	LC 7101
	Dairy cows and heifers in milk or calf over one year but under two years	LC 7102
	Dairy cows and heifers NOT in milk or calf two years old and over	LC 7103
	Dairy cows and heifers NOT in milk or calf over one year but under two years	LC 7104
	Dairy bulls to be used for dairy breeding	LC 7185
	TOTAL dairy cattle	LC 7193
Beef cattle	Beef cows/heifers in calf two years and over	LC7056
	Beef cows/heifers in calf over one year but under two years	LC 7057
	Beef cows/heifers NOT in calf two years and over	LC 7058
	Beef cows/heifers NOT in calf over one year but under two years	LC 7059
	Beef heifer and calves under one year old	LC 7064
	Steers two years and over	LC 7065
	Steers over one year but under two years	LC 7066
	Steers under one year old	LC 7067
	Non-breeding bulls two years and over	LC 7071
	Non-breeding bulls over one year but under two years	LC 7072
	Non-breeding bulls under one year old	LC 7073
	Breeding bulls (all ages)	LC 7068
	TOTAL beef cattle	LC 7077
Sheep	Lambs marked and/or tailed from ewe hoggets	LC 6700
	Lambs marked and/or tailed from ewes	LC 6701
	Rams (2 tooth and over)	LC 6720
	Ewes (2 tooth and over) put to ram	LC 6721
	Ewes (2 tooth and over) dry – not put to ram	LC 6722
	Ewe lambs and ewe hoggets put to ram	LC 6723
	Ewe lambs and ewe hoggets dry – not put to ram	LC 6724
	Wethers (2 tooth and over)	LC 6727
	Ram and wether lambs and wether hoggets	LC 6738
	TOTAL sheep	LC 6731
Deer	Deer females mated two years and over	LC 7600
	Deer females mated over one year but under two years	LC 7605
	Deer females NOT mated two years and over	LC 7610
	Deer females NOT mated over one year but under two years	LC 7615
	Deer females under one year old (include fawns still on the farm)	LC 7618
	Deer non-breeding males two years and over	LC 7620
	Deer breeding males two years old and over	LC 7645
	Deer males under one year old (include fawns still on the farm)	LC 7630
	Deer non-breeding males over one year but under two years	LC 7625
	Deer breeding males over one year but under two years	LC 7648
	Fawns born on farm and alive at four months	LC 7696
	TOTAL deer	LC 7699

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 A5.1.4 shows the proportions used to calculate milk yield for different months over the course of a year. Table A5.1.5 shows the emission factors used to calculate methane emissions from minor livestock species, while tables A5.1.6 and A5.1.7 show the emission factors used to calculate nitrous oxide (N₂O) emissions from agriculture. Table A5.1.8 shows some of the parameter values used to calculate N₂O emissions.

Table A5.1.4 Proportion of annual milk yield each month for major livestock categories

Month	Dairy cattle*	Beef cattle	Sheep	Deer
July	0.0133	0.0000	0.0000	0.0000
August	0.0597	0.0000	0.0000	0.0000
September	0.1117	0.1670	0.1639	0.0000
October	0.1350	0.1670	0.2541	0.0000
November	0.1269	0.1670	0.2459	0.1000
December	0.1195	0.1670	0.2541	0.2583
January	0.1078	0.1670	0.0820	0.2583
February	0.0871	0.1670	0.0000	0.2333
March	0.0927	0.0000	0.0000	0.1500
April	0.0818	0.0000	0.0000	0.0000
May	0.0535	0.0000	0.0000	0.0000
June	0.0110	0.0000	0.0000	0.0000

Source: Suttie (2012) and Pickering et al. (2024)

Note: All values presented in the table are rounded to four decimal places for presentation purposes and more precise values are available on request. *Monthly milk production data published on the Dairy Companies Association of New Zealand website is used to inform the milk produced in a given month as a proportion of total annual milk produced for dairy cattle, this is updated annually.

Table A5.1.5 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	Ritchie (2024)	Year specific (see chapter 5, section 5.2.2 for details)
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	Ritchie (2024)	Year specific (see chapter 5, section 5.3.2 for details)
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 CH₄/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 A5.1.6 Emission factors for New Zealand's agricultural nitrous oxide emissions

Emission factor	Emissions	Source	Parameter value
EF ₁ (kg N ₂ O-N/kg N)	Direct emissions from nitrogen input to soil	Kelliher and de Klein (2006)	0.01
EF _{1-UREA} (kg N ₂ O-N/kg N)	Direct emissions from nitrogen input to soil from urea fertiliser	van der Weerden et al. (2016)	0.0059
EF _{1-DAIRY} (kg N ₂ O-N/kg N)	Direct emissions from nitrogen input to soil from dairy cattle manure	van der Weerden et al. (2016)	0.0025
EF _{1-NMDF}	Direct emissions from non-manure organic nitrogen input to soil	IPCC (2019), table 11.1	0.006
EF ₂ (kg N ₂ O-N/ha-yr)	Direct emissions from organic soil mineralisation due to cultivation	IPCC (2006b), table 11.1	8.00
EF _{3PS} (kg N ₂ O-N/kg N excreted)	Direct emissions from waste in pit storage animal waste management systems	IPCC (2019), table 10.21	0.002
EF _{3DB} (kg N ₂ O-N/kg N excreted)	Direct emissions from waste in deep bedding animal waste management systems	IPCC (2019), table 10.21	0.01
EF _{3C} (kg N ₂ O-N/kg N excreted)	Direct emissions from waste in composting animal waste management systems	IPCC (2019), table 10.21	0.005
EF _{3AD} (kg N ₂ O-N/kg N excreted)	Direct emissions from waste in anaerobic digesters animal waste management systems	IPCC (2019), table 10.21	0.0006
EF _{3OTHER} (kg N ₂ O-N/kg N excreted)	Direct emissions from waste in other animal waste management systems	IPCC (2000), table 4.13	0.005
EF _{3(PRP-MINOR)} (kg N ₂ O-N/kg N excreted)	Direct emissions from manure (dung and urine) from minor grazing animals (i.e. <i>excluding</i> 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 ₂ O-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 A5.1.7)	van der Weerden et al. (2019)	0.0012
EF _{3POULTRY} (kg N ₂ O-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 ₂ O-N/kg NH _x -N)	Indirect emissions from volatilising nitrogen	IPCC (2006b), table 11.3	0.01
EF ₅ (kg N ₂ O-N/kg N leached and runoff)	Indirect emissions from leaching nitrogen	IPCC (2006b), table 11.3	0.0075

Table A5.1.7 Direct nitrous oxide emission factors for urine deposited by cattle, sheep and deer, by livestock type and slope

Livestock type	Emission factor by topography (kg N ₂ O-N/kg N excreted)	
	Flat and low sloped land (less than 12-degree gradient)	Medium and steep sloped land (greater than 12-degree gradient)
	EF _{3(PRP-FLAT)}	EF _{3(PRP-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 A5.1.8 Parameter values for New Zealand's agriculture nitrous oxide emissions

Parameter (fraction)	Fraction of the parameter	Source	Parameter value
Fra _{C_{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
Fra _{C_{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
Fra _{C_{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)
Fra _{C_{BURN}} (kg N/kg crop-N)	Crop residue burned in fields	Thomas et al. (2008), table 14	Crop specific survey data
Fra _{C_{BURNL}} (kg N/kg legume-N)	Legume crop residue burned in fields	Thomas et al. (2008), practice does not occur in New Zealand	0
Fra _{C_{RENEW}}	Fraction of land undergoing pasture renewal	Thomas et al. (2014)	Year specific
Fra _{C_{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
Fra _{C_{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 A5.1.9. These values are taken from research conducted by Thomas et al. (2008, 2011).

Table A5.1.9 Parameter values for New Zealand's cropping emissions

Crop	HI	d _{mf}	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; d_{mf} = 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 N₂O 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 (N) (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 Agriculture 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. The most recently provided data from Beef + Lamb New Zealand Ltd is for 2022, the proportions of animals on different farm and slope classes are assumed to be the same in 2023.

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 ('Nitrogen excretion rates for the major livestock categories'), and in chapter 5 of Pickering et al. (2024).

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. (2018), and section 5.2.4 (beef cattle), section 5.3.5 (sheep) and section 5.4.5 (deer) of Pickering et al. (2024).

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 A5.1.10 and figure A5.1.1 and figure 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 ($0.45 \times 60 \text{ per cent} + 0.45 = 72 \text{ per cent}$) 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 ($EF_{3(PRP-DUNG)} = 0.0012$) is used across all slope categories for cattle, sheep and deer. Therefore, dung excreta do not need to be allocated to different slopes.

Table A5.1.10 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 low slope land	
Percentage of low slope 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 (0–12-degree) slopes using a nutrient transfer model (equal proportion line shown in grey for comparison)

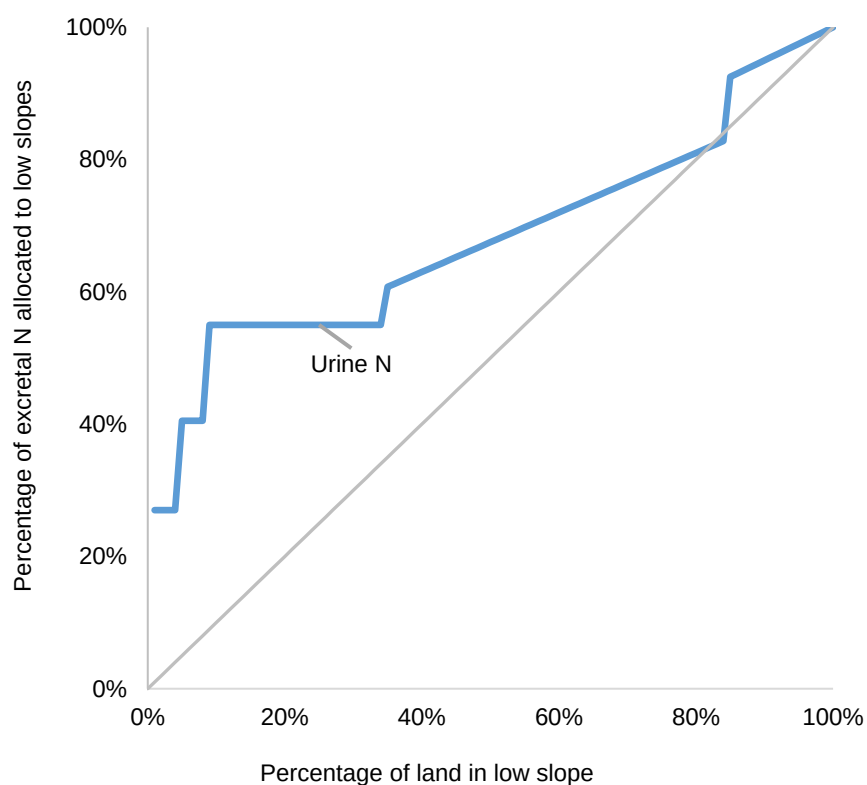
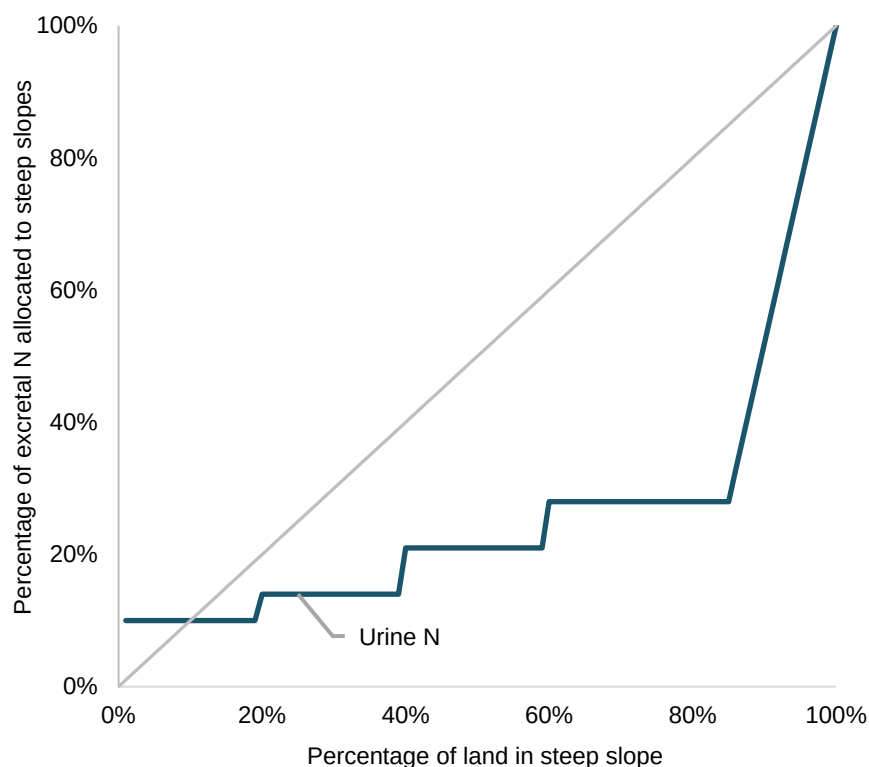


Figure A5.1.2 Proportion of urine nitrogen (N) applied to steep (more than 24-degree) slopes using a nutrient transfer model (equal proportion line shown in grey for comparison)



Tables A5.1.11 to A5.1.13 and figure A5.1.3 provide examples of how this nutrient allocation methodology uses Beef + Lamb New Zealand Ltd data to allocate urine 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) to these different farm classes (table A5.1.11 and table A5.1.12).

Table A5.1.11 Share of livestock population, and amount of urine nitrogen (N) deposition in 2023, by Beef + Lamb New Zealand Ltd farm class (using 2022 data)

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	18,586,570	3.0	7,213,431	14.0	2,039,116
2. South Island Hill Country	11.7	32,098,727	7.6	17,984,720	6.3	919,845
3. North Island Hard Hill Country	17.1	46,963,513	14.8	35,196,428	9.0	1,309,180
4. North Island Hill Country	26.2	72,164,824	40.8	96,726,519	29.1	4,259,048
5. North Island Intensive Finishing	5.6	15,416,941	12.2	28,997,046	0.4	54,918
6. South Island Finishing Breeding	19.2	52,934,061	14.4	34,060,982	24.9	3,635,615
7. South Island Intensive Finishing	10.4	28,577,125	2.7	6,384,145	11.9	1,736,218
8. South Island Mixed Finishing	3.0	8,308,650	4.5	10,716,576	4.5	657,075
Total		275,050,411		237,279,847		14,611,015

Each farm class has a different proportion of land in low, medium and steep slopes, as shown in table A5.1.12. 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 and farm classes, as shown in table A5.1.13. From this point, direct N₂O emissions can be calculated using the emission factors in chapter 5, table 5.5.3.

Table A5.1.12 Percentage of total sheep, beef and deer land on different hill slopes, by Beef + Lamb New Zealand Ltd farm class for 2023 (using 2022 data)

Farm class	Land type by slope		
	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

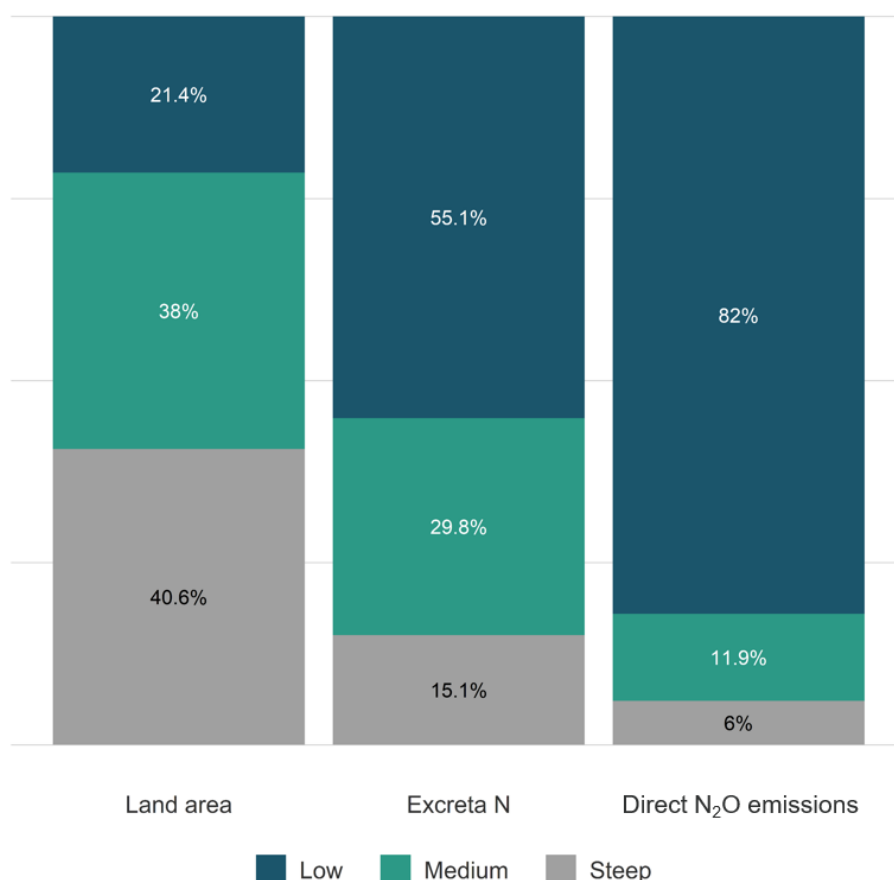
Note: The percentages may not add up to 100 per cent due to rounding.

Table A5.1.13 Proportion of total sheep, beef and deer urine nitrogen deposited on different hill slopes, by Beef + Lamb New Zealand Ltd farm class for 2023 (using 2022 data)

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	0.11	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 (N₂O) emissions by hill slope category for sheep, beef cattle and deer farms in 2023



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 2023 are based on five full-coverage (wall-to-wall) national land use maps 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 2023.

Satellite image acquisition and pre-processing

Each of the national land use maps is based on a collection of satellite imagery from Landsat, SPOT² 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.

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

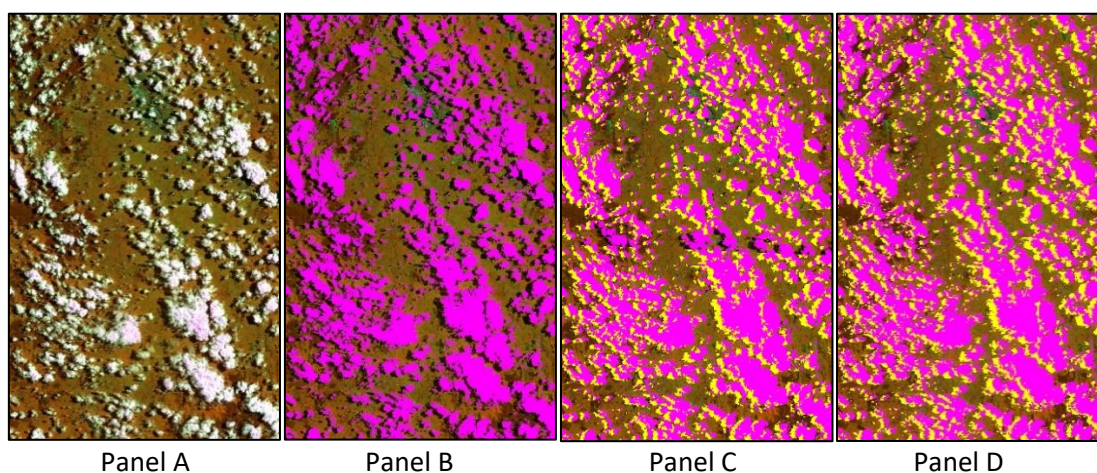
Table A5.2.1 Satellite imagery used for land use mapping in 1989, 2007, 2012, 2016 and 2020

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 land use map 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 of 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 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 (less than 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).

Figure A5.2.1 Classification steps in cloud-masking workflow

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., 2023).

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: 15 metres at 1989 (resampled) versus 10 metres at 2007.

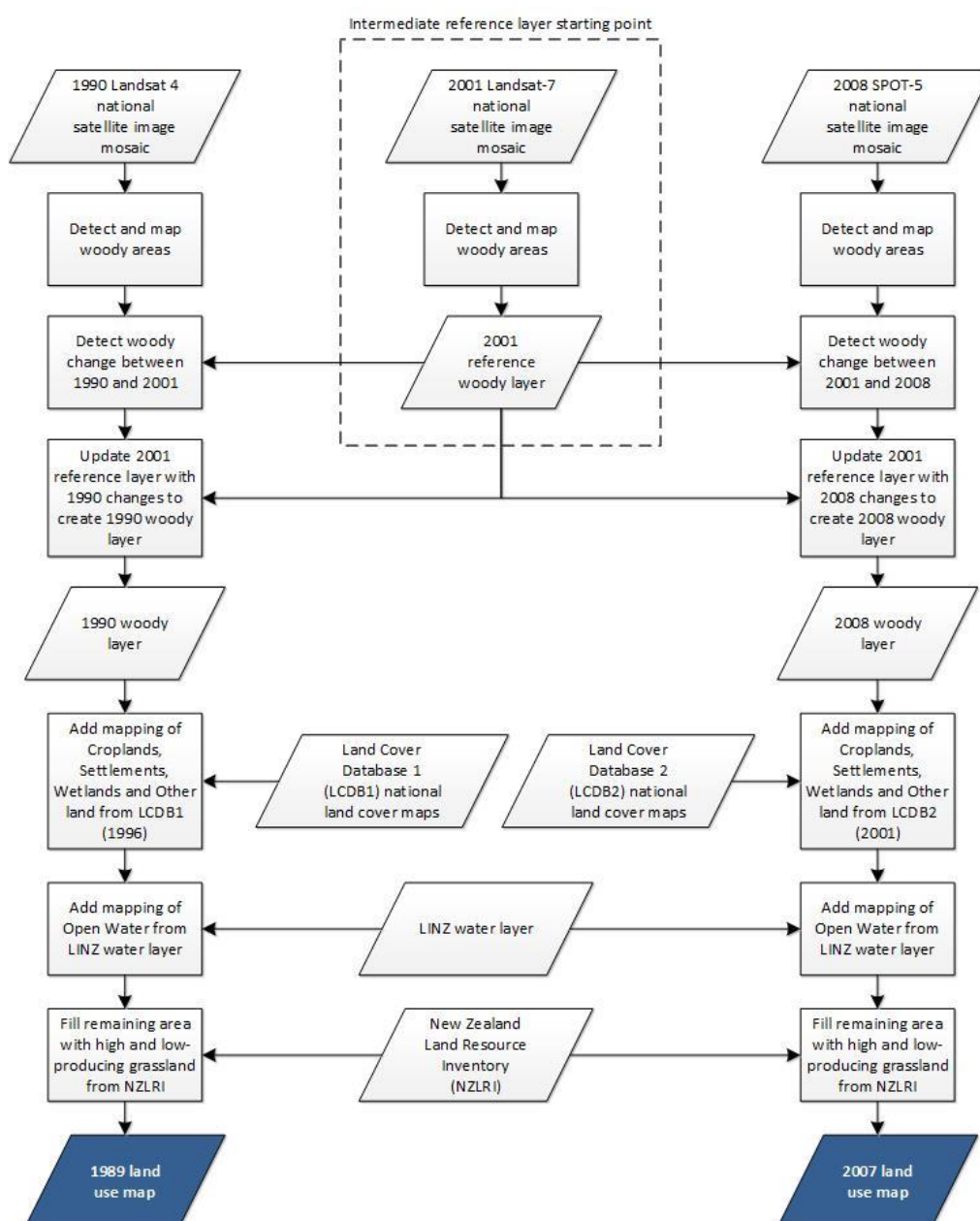
Area, proximity and temporal rules were used to convert these layers from woody land cover to woody land use classes, making allowances for unstocked areas within forest extents and areas of regenerating vegetation in a forest context. This process is described in Shepherd and Newsome (unpublished(a)).

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.

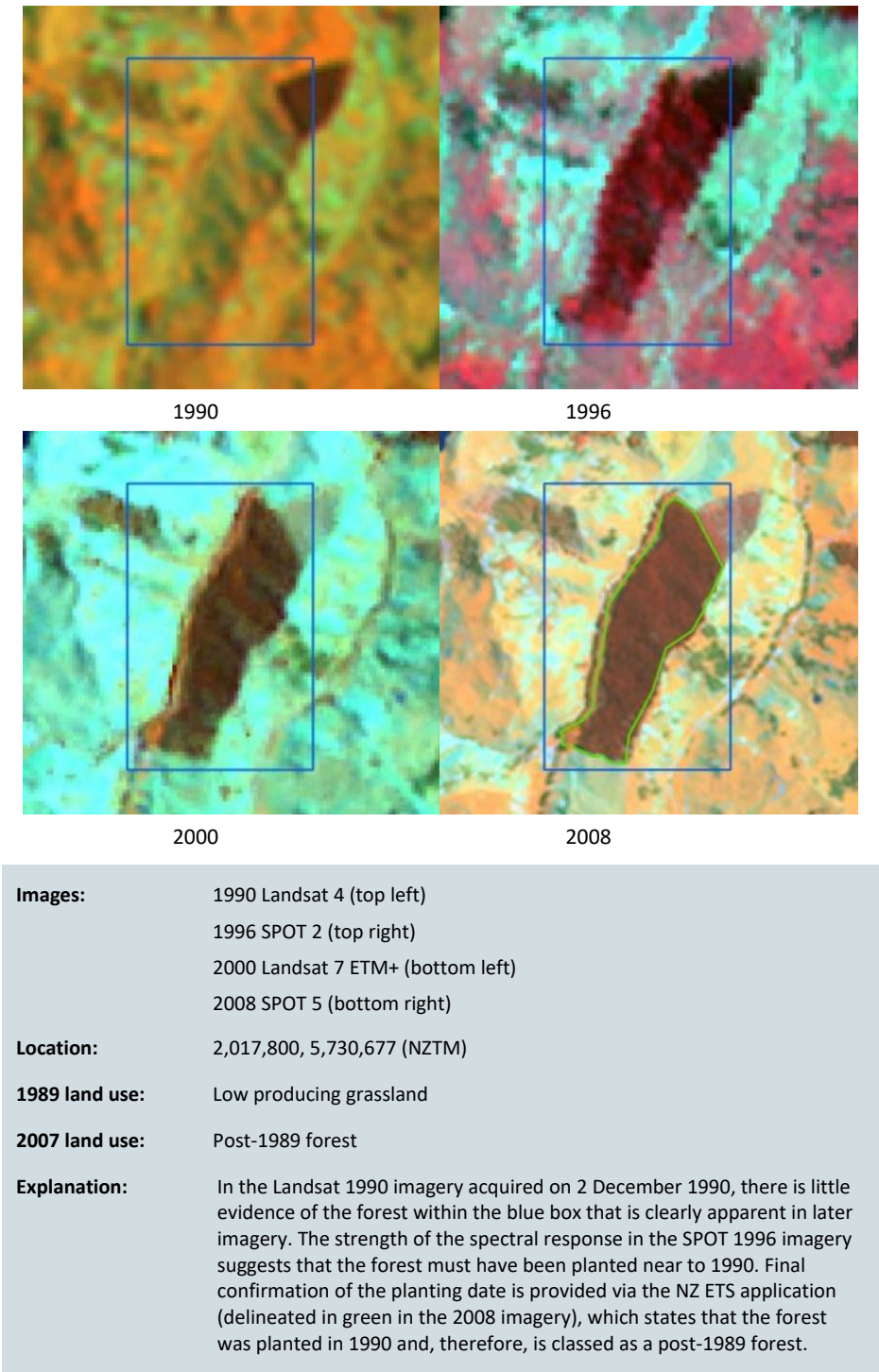
Owners of post-1989 forest may apply to lodge their forests within the NZ ETS to obtain credit for increases in carbon stock since 1 January 2008. Mapping received by Te Uru Rākau – New Zealand Forest Service for these applications is used to improve the Land Use and Carbon Analysis System (LUCAS) land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

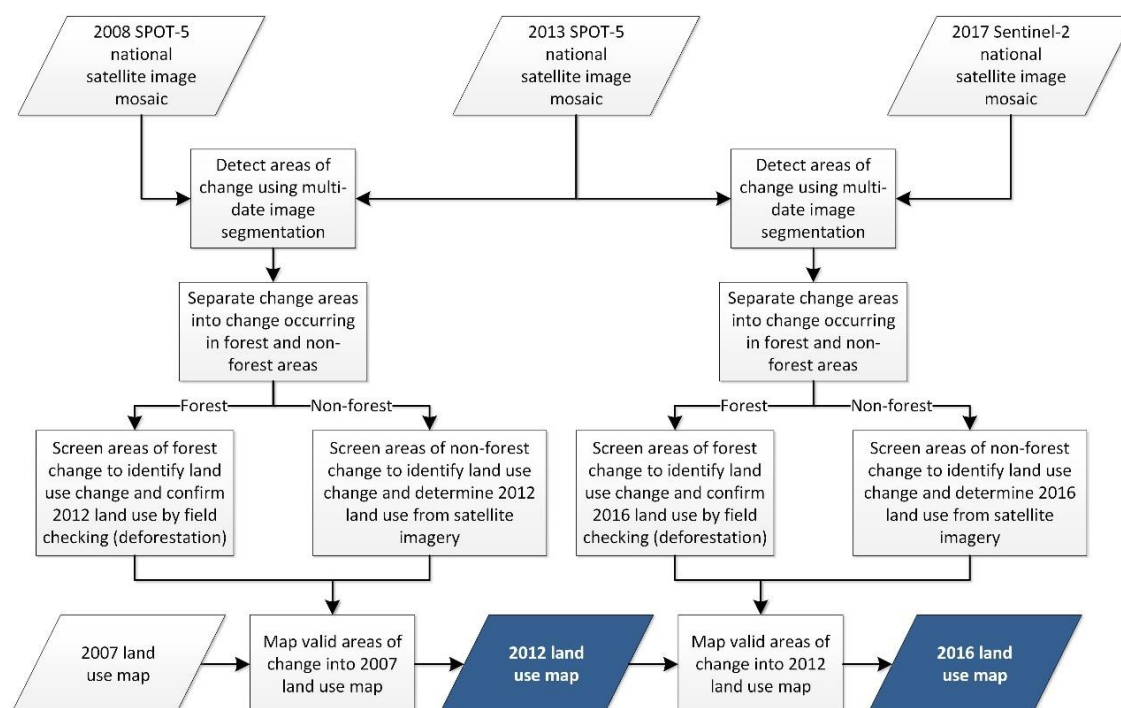
Figure A5.2.3 Identification of post-1989 forest in New Zealand



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 incorporating all of 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 into 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	15	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	15	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 changes 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 destocking 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 years⁴ 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.

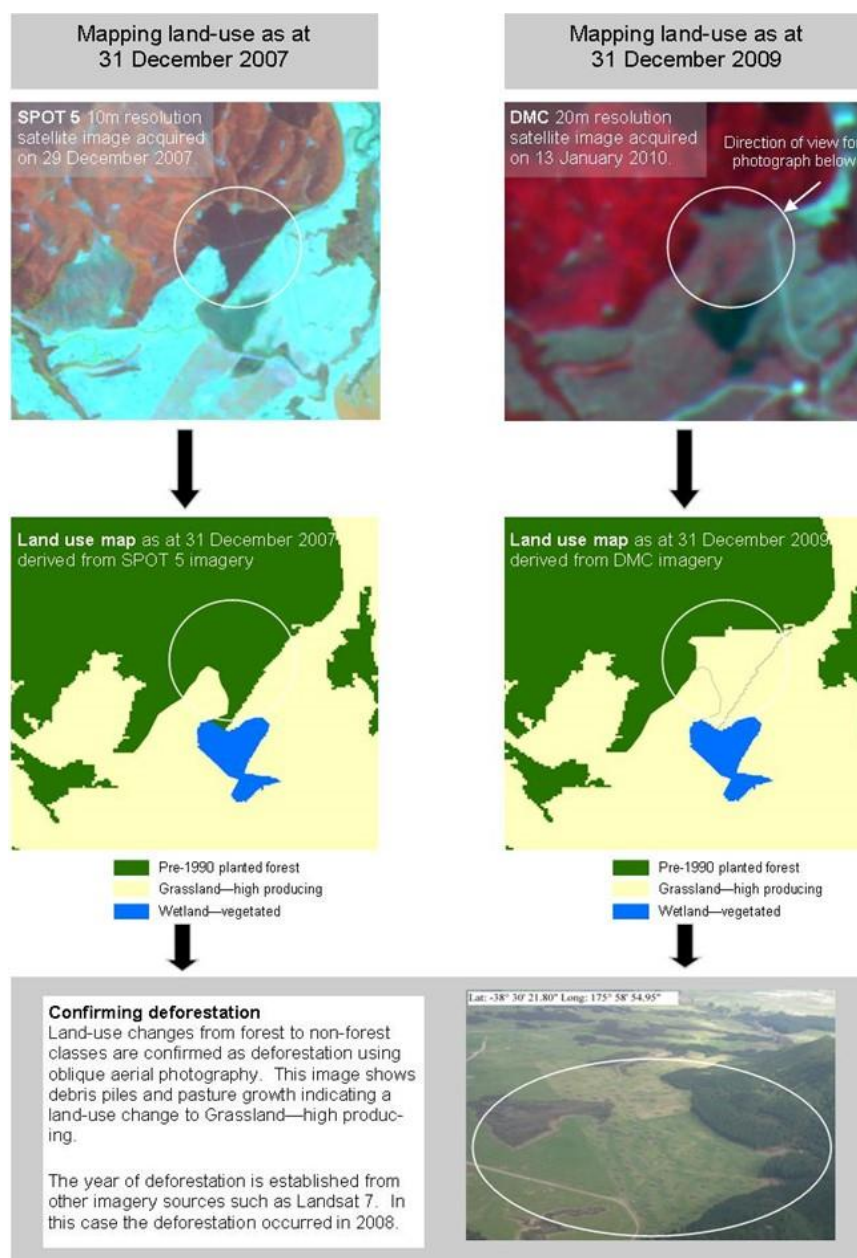
For each deforested area, further information was then recorded, such as the year in which the deforestation occurred. This was determined by examining the ancillary imagery data sets listed in table A5.2.2. Figure A5.2.5 shows the process of confirming deforestation and establishing the year in which 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 changes detected between 2016 and 2020 were 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.

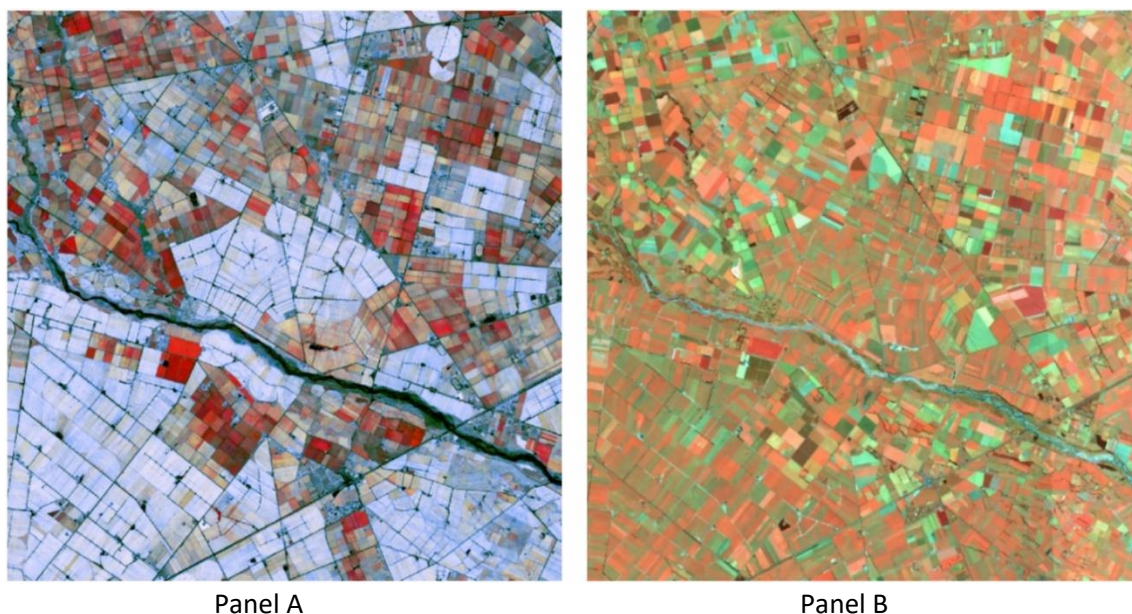
As part of the 2020 land use mapping process, an assessment was made of the potential of deep learning mapping methods to derive independent 2016 and 2020 maps of land cover that related to the land use map classes. These land cover classes included indigenous and exotic forests. The deep learning model was trained on a land cover derivative of the 2016 land use map and then used to predict the 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 because 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 more likely to be grassland, whereas areas that were often cultivated were more likely to be cropland (Harris et al., 2023). Figure A5.2.6 (panel 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 (panel B).

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



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 to 2020 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., 2023).

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 centimetre) 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 <i>Pinus radiata</i> (radiata pine) and <i>Pseudotsuga menziesii</i> (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
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.

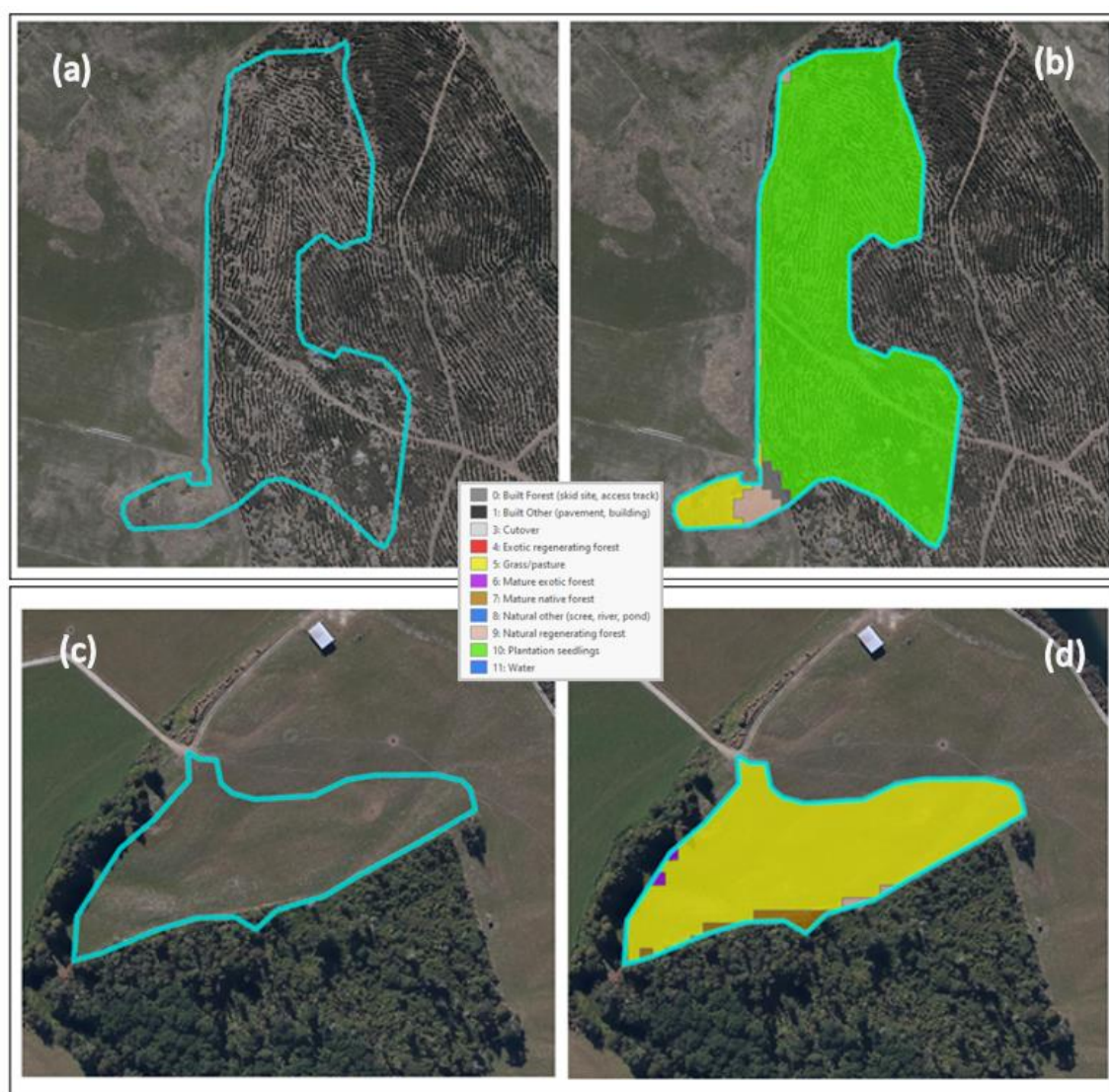
Table A5.2.4 Criteria used to determine deforestation status of each area of destocking based on the proportions of different types of land cover identified by machine learning process

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 regeneration 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 and 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 detection of destocking 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. (2023) 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 assessment requires careful scrutiny, 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, 2024a).
- 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

Afforestation type	Reporting years: 2008–16		Reporting years: 2017–20	
	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 New Zealand Emissions Trading Scheme	Based on mapping from national forestry schemes including the New Zealand Emissions Trading Scheme
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

Estimating land-use change for 2021 to 2023

Activity data for the three most recent years of this inventory, from 2021 to 2023, have been estimated from a survey for afforestation (Ministry for Primary Industries, 2024a) 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 to 2023 has been extrapolated from the total annual mapped planted forest deforestation over 2014 to 2020. Over this period, a downward trend has occurred 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 2023 (Manley, 2024). To more accurately estimate the proportions of pre-1990 and post-1989 planted forest deforestation occurring during 2021 to 2023, 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 to 2023 to obtain the pre-1990 planted forest deforestation estimates for those years. The post-1989 planted forest deforestation estimates for 2021 to 2023 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 between 2021 and 2023 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 over 2017 to 2020.

Afforestation

The annual area of afforestation of post-1989 planted forest for 2021 to 2023 is based on estimates from the NEFD (Ministry for Primary Industries, 2024a). The annual area of afforestation of post-1989 natural forest for 2017 to 2021 is estimated from the Ministry for Primary Industries afforestation scheme data. The area of post-1989 natural afforestation for 2022 to 2023 is estimated from the Ministry for Primary Industries Afforestation and Deforestation Intentions Survey for 2023 using the total areas of 'natural reversion' and 'indigenous tall planted' (Manley, 2024).

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 2023.

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 2023 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 2020 land use map into the reporting cycle for the 2024 inventory submission, replacing 2017 to 2020 extrapolated activity data with interpolated data with a mapped end point at 2020, a corresponding emission increase of approximately 54 kilotonnes carbon dioxide equivalent (0.3 per cent) was reported in the recalculation for 2021 emissions, indicating that the error introduced by extrapolation is unlikely to be large.

A5.2.3 Annual land-use change summary

This section contains a summary of the annual land-use change from 1990 to 2023 (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	-	82	-	-	-	-	-	-	-	-	-	-	-
	1991	-	82	-	-	-	-	-	-	-	-	-	-	-
	1992	-	82	-	-	-	-	-	-	-	-	-	-	-
	1993	-	82	-	-	-	-	-	-	-	-	-	-	-
	1994	-	82	-	-	-	-	-	-	-	-	-	-	-
	1995	-	82	-	-	-	-	-	-	-	-	-	-	-
	1996	-	82	-	-	-	-	-	-	-	-	-	-	-
	1997	-	82	-	-	-	-	-	-	-	-	-	-	-
	1998	-	82	-	-	-	-	-	-	-	-	-	-	-
	1999	-	82	-	-	-	-	-	-	-	-	-	-	-
	2000	-	82	-	-	-	-	-	-	-	-	-	-	-
	2001	-	82	-	-	-	-	-	-	-	-	-	-	-
	2002	-	82	-	-	-	-	-	-	-	-	-	-	-
	2003	-	82	-	-	-	-	-	-	-	-	-	-	-
	2004	-	82	-	-	-	-	-	-	-	-	-	-	-
	2005	-	82	-	-	-	-	-	-	-	-	-	-	-
	2006	-	82	-	-	-	-	-	-	-	-	-	-	-
	2007	-	82	-	-	-	-	-	-	-	-	-	-	-
	2008	-	351	-	-	-	-	5	-	3	-	-	-	-
	2009	-	351	-	-	-	-	5	-	3	-	-	-	-
	2010	-	351	-	-	-	-	5	-	3	-	-	-	-
	2011	-	351	-	-	-	-	5	-	3	-	-	-	-

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	-	351	-	-	-	-	5	-	3	-	-	-	-
	2013	-	92	-	-	-	-	5	3	40	-	-	-	-
	2014	-	89	-	-	-	-	5	3	40	-	-	-	-
	2015	-	89	-	-	-	-	5	3	40	-	-	-	-
	2016	-	89	-	-	-	-	5	3	40	-	-	-	-
	2017	-	-	-	-	-	-	32	27	0	-	-	-	-
	2018	-	-	-	-	-	-	21	-	-	-	-	-	-
	2019	-	-	-	-	-	-	21	-	-	-	-	-	-
	2020	-	-	-	-	-	-	21	1	-	-	-	-	-
	2021	-	-	-	-	-	-	-	-	-	-	-	-	-
	2022	-	-	-	-	-	-	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-	-	-	-	-	-	-
Pre-1990 planted forest	1990	1,280	-	-	-	-	-	-	-	-	-	-	-	-
	1991	1,280	-	-	-	-	-	-	-	-	-	-	-	-
	1992	1,280	-	-	-	-	-	-	-	-	-	-	-	-
	1993	1,280	-	-	-	-	-	-	-	-	-	-	-	-
	1994	1,280	-	-	-	-	-	-	-	-	-	-	-	-
	1995	1,280	-	-	-	-	-	-	-	-	-	-	-	-
	1996	1,280	-	-	-	-	-	-	-	-	-	-	-	-
	1997	1,280	-	-	-	-	-	-	-	-	-	-	-	-
	1998	1,280	-	-	-	-	-	-	-	-	-	-	-	-
	1999	1,280	-	-	-	-	-	-	-	-	-	-	-	-
	2000	1,280	-	-	-	-	-	-	-	-	-	-	-	-
	2001	1,280	-	-	-	-	-	-	-	-	-	-	-	-
	2002	1,280	-	-	-	-	-	-	-	-	-	-	-	-
	2003	1,286	-	-	-	-	-	-	-	-	-	-	-	-

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	1,280	-	-	-	-	-	-	-	-	-	-	-	-
	2005	1,280	-	-	-	-	-	-	-	-	-	-	-	-
	2006	1,280	-	-	-	-	-	-	-	-	-	-	-	-
	2007	1,280	-	-	-	-	-	-	-	-	-	-	-	-
	2008	168	-	-	-	-	-	12	9	23	-	1	-	-
	2009	168	-	-	-	-	-	12	9	23	-	1	-	-
	2010	168	-	-	-	-	-	12	9	23	-	1	-	-
	2011	168	-	-	-	-	-	16	9	23	-	1	-	-
	2012	168	-	-	-	-	-	12	9	23	-	1	-	-
	2013	41	-	-	-	-	-	31	82	129	-	-	-	-
	2014	41	-	-	-	-	-	27	90	82	-	-	-	-
	2015	41	-	-	-	-	-	27	92	78	-	-	-	-
	2016	41	-	-	-	-	-	27	91	80	-	-	-	-
	2017	71	-	-	-	-	-	19	62	50	-	-	-	-
	2018	71	-	-	-	-	-	18	92	220	-	-	-	0
	2019	71	-	-	-	-	-	133	139	56	-	-	-	-
	2020	71	-	-	-	-	-	51	174	63	-	-	-	-
	2021	71	-	-	-	-	-	-	-	-	-	-	-	-
	2022	71	-	-	-	-	-	-	-	-	-	-	-	-
	2023	71	-	-	-	-	-	-	-	-	-	-	-	-
Post-1989 planted forest	1990	-	-	-	-	10	0	2,717	8,004	2,892	1	29	-	65
	1991	-	-	-	-	10	0	2,648	7,810	2,819	1	28	-	64
	1992	-	-	-	-	36	1	8,652	25,473	9,202	5	91	-	208
	1993	-	-	-	-	38	1	10,610	31,226	11,284	6	111	-	256
	1994	-	-	-	-	61	2	16,921	49,764	18,014	9	178	-	406
	1995	-	-	-	-	46	1	12,707	37,544	13,546	7	134	-	306

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
	1996	-	-	-	-	52	1	14,377	42,588	15,322	8	151	-	346
	1997	-	-	-	-	40	1	10,977	32,375	11,689	6	115	-	263
	1998	-	-	-	-	32	1	8,812	25,985	9,376	5	93	-	212
	1999	-	-	-	-	25	1	6,892	20,299	7,322	4	72	-	165
	2000	-	-	-	-	21	1	5,777	17,172	6,150	3	61	-	139
	2001	-	-	-	-	19	1	5,180	15,256	5,516	3	54	-	125
	2002	-	-	-	-	14	0	3,800	11,198	4,045	2	40	-	91
	2003	-	-	-	-	12	0	3,422	10,081	3,644	2	36	-	82
	2004	-	-	-	-	7	0	1,823	5,370	1,940	1	19	-	44
	2005	-	-	-	-	4	0	1,032	3,070	1,098	1	11	-	25
	2006	-	-	-	-	2	0	447	1,317	476	0	5	-	11
	2007	-	-	-	-	1	0	413	1,216	439	0	4	-	10
	2008	-	-	-	-	1	-	586	1,708	465	-	2	0	12
	2009	-	-	-	-	2	-	1,327	3,865	1,037	-	5	0	14
	2010	-	-	-	-	3	-	1,852	5,393	1,447	-	8	0	19
	2011	-	-	-	-	7	-	3,704	10,785	2,894	-	15	0	38
	2012	-	-	-	-	6	-	3,549	10,336	2,773	-	15	0	37
	2013	-	-	-	-	-	-	1,151	4,063	1,048	-	2	-	1
	2014	-	-	-	-	-	-	867	3,093	767	-	2	-	1
	2015	-	-	-	-	-	-	867	3,094	768	-	2	-	1
	2016	-	-	-	-	-	-	411	2,024	376	-	1	-	0
	2017	-	-	-	-	11	-	2,315	3,307	893	-	-	-	-
	2018	-	-	-	-	13	-	2,715	4,364	543	-	-	-	-
	2019	-	-	-	-	48	-	9,097	10,618	1,684	-	-	-	-
	2020	-	-	-	-	88	-	16,670	18,933	2,871	-	-	-	-
	2021	-	-	-	-	117	-	22,238	24,941	3,818	-	-	-	-

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
	2022	-	-	-	-	182	-	34,611	38,819	5,943	-	-	-	-
	2023	-	-	-	-	178	-	33,888	38,008	5,819	-	-	-	-
Post-1989 natural forest	1990	-	-	-	-	0	0	40	438	489	-	0	-	11
	1991	-	-	-	-	0	0	46	511	570	-	0	-	12
	1992	-	-	-	-	0	0	53	584	652	-	0	-	14
	1993	-	-	-	-	0	0	46	511	570	-	0	-	12
	1994	-	-	-	-	0	0	40	438	489	-	0	-	11
	1995	-	-	-	-	0	0	33	365	407	-	0	-	9
	1996	-	-	-	-	0	0	33	365	407	-	0	-	9
	1997	-	-	-	-	0	0	106	1,169	1,305	-	0	-	28
	1998	-	-	-	-	0	0	119	1,314	1,466	-	0	-	32
	1999	-	-	-	-	0	0	133	1,460	1,629	-	0	-	35
	2000	-	-	-	-	0	0	166	1,824	2,037	-	0	-	44
	2001	-	-	-	-	0	0	199	2,189	2,444	-	0	-	53
	2002	-	-	-	-	0	0	159	1,751	1,955	-	0	-	42
	2003	-	-	-	-	0	0	179	1,970	2,200	-	0	-	48
	2004	-	-	-	-	0	0	239	2,627	2,933	-	0	-	64
	2005	-	-	-	-	0	0	279	3,065	3,422	-	0	-	74
	2006	-	-	-	-	0	0	319	3,503	3,910	-	0	-	85
	2007	-	-	-	-	0	0	299	3,284	3,666	-	0	-	80
	2008	-	-	-	-	-	-	36	648	1,054	-	-	-	3
	2009	-	-	-	-	-	-	36	648	1,011	-	-	-	3
	2010	-	-	-	-	-	-	36	648	1,011	-	-	-	3
	2011	-	-	-	-	-	-	36	648	1,011	-	-	-	3
	2012	-	-	-	-	-	-	36	648	1,011	-	-	-	3
	2013	-	-	-	-	-	-	97	1,372	519	-	-	-	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
	2014	-	-	-	-	-	-	97	1,372	515	-	-	-	2
	2015	-	-	-	-	-	-	97	1,372	515	-	-	-	2
	2016	-	-	-	-	-	-	116	1,415	515	-	-	-	2
	2017	-	-	-	-	-	-	1,699	2,114	954	-	-	-	-
	2018	-	-	-	-	-	-	1,404	1,746	701	-	-	-	-
	2019	-	-	-	-	-	-	1,992	2,478	995	-	-	-	-
	2020	-	-	-	-	-	-	1,910	2,375	953	-	-	-	-
	2021	-	-	-	-	-	-	1,484	1,846	741	-	-	-	-
	2022	-	-	-	-	-	-	2,490	3,096	1,243	-	-	-	-
	2023	-	-	-	-	-	-	2,016	2,507	1,006	-	-	-	-
	1990	1	-	-	-	-	83	1,264	38	5	-	1	-	-
Annual cropland	1991	1	-	-	-	-	83	1,264	38	5	-	1	-	-
	1992	1	-	-	-	-	83	1,264	38	5	-	1	-	-
	1993	1	-	-	-	-	83	1,264	38	5	-	1	-	-
	1994	1	-	-	-	-	83	1,264	38	5	-	1	-	-
	1995	1	-	-	-	-	83	1,264	38	5	-	1	-	-
	1996	1	-	-	-	-	83	1,264	38	5	-	1	-	-
	1997	1	-	-	-	-	83	1,264	38	5	-	1	-	-
	1998	1	-	-	-	-	83	1,264	38	5	-	1	-	-
	1999	1	-	-	-	-	83	1,264	38	5	-	1	-	-
	2000	1	9	-	-	-	83	1,264	38	5	-	1	-	-
	2001	1	8	-	-	-	83	1,264	38	5	-	1	-	-
	2002	1	6	3	-	-	83	1,264	38	5	-	1	-	-
	2003	1	12	10	-	-	83	1,264	38	5	-	1	-	-
	2004	1	28	9	-	-	83	1,264	38	5	-	1	-	-
	2005	1	57	10	-	-	83	1,264	38	5	-	1	-	-

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
	2006	1	72	9	-	-	83	1,264	38	5	-	1	-	-
	2007	1	96	20	-	-	83	1,264	38	5	-	1	-	-
	2008	-	34	7	-	-	176	60	13	9	0	-	0	-
	2009	-	3	2	-	-	176	60	13	9	0	-	0	-
	2010	3	10	37	-	-	176	60	13	9	0	-	0	-
	2011	-	14	20	-	-	176	60	13	9	0	-	0	-
	2012	-	6	14	-	-	176	60	13	9	0	-	0	-
	2013	3	97	58	-	-	0	9	4	4	-	-	-	-
	2014	6	35	32	-	-	0	6	4	4	-	-	-	-
	2015	7	4	4	-	-	0	6	4	4	-	-	-	-
	2016	-	14	12	-	-	0	6	4	4	-	-	-	-
	2017	-	4	20	-	-	-	16,319	215	55	-	-	-	-
	2018	-	2	6	-	-	-	16,319	215	55	-	-	-	-
	2019	-	12	15	-	-	-	16,327	216	55	-	-	-	-
	2020	-	4	9	-	-	-	16,310	215	55	-	-	-	-
	2021	-	-	-	-	-	-	14,281	214	50	-	-	-	-
	2022	-	-	-	-	-	-	14,281	214	50	-	-	-	-
	2023	-	-	-	-	-	-	14,281	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	-

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
	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	-
	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	11	-	332	-	1,639	157	21	0	0	0	-
	2007	3	106	28	-	332	-	1,639	157	21	0	0	0	-
	2008	-	-	-	-	123	-	444	49	2	-	-	-	-
	2009	-	11	2	-	123	-	444	49	2	-	-	-	-
	2010	-	-	-	-	123	-	444	49	2	-	-	-	-
	2011	-	-	-	-	130	-	444	49	2	-	-	-	-
	2012	-	-	-	-	123	-	444	49	2	-	-	-	-
	2013	-	-	-	-	290	-	354	2	4	-	-	-	1
	2014	-	2	-	-	290	-	354	2	4	-	-	-	1
	2015	-	-	-	-	290	-	356	2	4	-	-	-	1
	2016	-	5	-	-	301	-	354	2	7	-	-	-	1
	2017	-	-	-	-	246	-	159	2	1	-	-	-	-
	2018	-	6	5	-	226	-	181	6	1	-	-	-	-
	2019	2	45	6	-	226	-	164	2	1	-	-	-	-
	2020	-	18	-	-	226	-	159	2	1	-	-	-	-
	2021	-	-	-	-	147	-	148	2	1	-	-	-	-
	2022	-	-	-	-	147	-	148	2	1	-	-	-	-
	2023	-	-	-	-	147	-	148	2	1	-	-	-	-

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
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
	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	635	-	101	185	-	55,081	1,173	6	242	0	6
	2003	568	2,156	2,003	-	101	185	-	55,081	1,173	6	242	0	6
	2004	568	4,970	1,840	-	101	185	-	55,081	1,173	6	242	0	6
	2005	568	10,194	2,093	-	101	185	-	55,081	1,173	6	242	0	6
	2006	568	12,829	1,794	-	101	185	-	55,081	1,173	6	242	0	6
	2007	568	17,023	4,306	-	101	185	-	55,081	1,173	6	242	0	6
	2008	278	2,414	924	2	8	195	-	7,566	1,456	3	291	-	19
	2009	648	3,165	898	10	8	195	-	7,566	1,457	3	291	-	19
	2010	471	3,526	1,034	5	8	195	-	7,566	1,456	3	291	-	19
	2011	229	2,657	1,184	4	17	195	-	7,566	1,456	3	291	-	19
	2012	161	4,644	773	4	8	195	-	7,566	1,456	3	291	-	19
	2013	234	6,539	1,685	12	9,289	3	-	15,187	958	0	114	-	1
	2014	155	4,197	1,328	-	9,289	3	-	15,187	968	0	114	-	1
	2015	290	2,715	1,597	9	9,289	3	-	15,187	963	0	114	-	1

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	130	2,598	1,963	6	9,289	3	-	15,187	958	0	114	-	1
	2017	116	1,846	1,916	3	7,622	-	-	2,953	667	1	0	2	-
	2018	208	1,199	2,524	10	7,622	-	-	2,953	666	1	0	2	-
	2019	126	681	1,143	55	7,625	-	-	2,958	668	1	0	2	-
	2020	109	794	2,547	14	7,619	-	-	2,948	681	1	0	2	-
	2021	149	788	1,273	81	6,994	-	-	2,736	529	1	0	-	-
	2022	149	227	1,542	81	6,994	-	-	2,736	529	1	0	-	-
	2023	149	143	1,128	81	6,994	-	-	2,736	529	1	0	-	-
Grassland – low producing	1990	902	-	-	-	0	4	1	-	1,381	7	74	-	18
	1991	902	-	-	-	0	4	1	-	1,381	7	74	-	18
	1992	902	-	-	-	0	4	1	-	1,381	7	74	-	18
	1993	902	-	-	-	0	4	1	-	1,381	7	74	-	18
	1994	902	-	-	-	0	4	1	-	1,381	7	74	-	18
	1995	902	-	-	-	0	4	1	-	1,381	7	74	-	18
	1996	902	-	-	-	0	4	1	-	1,381	7	74	-	18
	1997	902	-	-	-	0	4	1	-	1,381	7	74	-	18
	1998	902	-	-	-	0	4	1	-	1,381	7	74	-	18
	1999	902	-	-	-	0	4	1	-	1,381	7	74	-	18
	2000	902	295	-	-	0	4	1	-	1,381	7	74	-	18
	2001	902	282	-	-	0	4	1	-	1,381	7	74	-	18
	2002	902	191	106	-	0	4	1	-	1,381	7	74	-	18
	2003	902	420	335	-	0	4	1	-	1,381	7	74	-	18
	2004	902	968	308	-	0	4	1	-	1,381	7	74	-	18
	2005	902	1,985	350	-	0	4	1	-	1,381	7	74	-	18
	2006	902	2,498	300	-	0	4	1	-	1,381	7	74	-	18
	2007	902	3,315	720	-	0	4	1	-	1,381	7	74	-	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
	2008	312	1,012	177	4	-	3	547	-	2,484	4	95	-	35
	2009	801	1,345	932	23	-	3	547	-	2,484	4	95	-	35
	2010	509	2,179	463	8	-	3	547	-	2,484	4	95	-	35
	2011	304	2,058	830	84	-	3	547	-	2,484	4	95	-	35
	2012	339	2,381	436	15	-	3	547	-	2,484	4	95	-	35
	2013	478	2,254	771	30	-	-	285	-	1,734	5	31	166	37
	2014	246	2,274	706	18	-	-	285	-	1,744	5	31	166	37
	2015	181	1,607	727	26	-	-	285	-	1,734	5	31	166	37
	2016	183	1,660	1,163	47	-	-	285	-	1,734	5	31	166	37
	2017	168	1,032	1,739	46	0	-	341	-	1,877	-	5	0	-
	2018	264	638	1,430	56	0	-	341	-	1,906	-	5	0	-
	2019	158	545	675	24	0	-	341	-	1,905	-	5	0	-
	2020	170	755	1,517	31	0	-	341	-	1,867	-	5	0	-
	2021	199	481	755	48	0	-	338	-	1,412	-	5	-	-
	2022	199	77	915	48	0	-	338	-	1,412	-	5	-	-
	2023	199	92	669	48	0	-	338	-	1,412	-	5	-	-
Grassland – with woody biomass	1990	308	-	-	-	3	7	740	3,728	-	13	1	0	71
	1991	308	-	-	-	3	7	740	3,728	-	13	1	0	71
	1992	308	-	-	-	3	7	740	3,728	-	13	1	0	71
	1993	308	-	-	-	3	7	740	3,728	-	13	1	0	71
	1994	308	-	-	-	3	7	740	3,728	-	13	1	0	71
	1995	308	-	-	-	3	7	740	3,728	-	13	1	0	71
	1996	308	-	-	-	3	7	740	3,728	-	13	1	0	71
	1997	308	-	-	-	3	7	740	3,728	-	13	1	0	71
	1998	308	-	-	-	3	7	740	3,728	-	13	1	0	71
	1999	308	-	-	-	3	7	740	3,728	-	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
	2000	308	168	-	-	3	7	740	3,728	-	13	1	0	71
	2001	308	162	-	-	3	7	740	3,728	-	13	1	0	71
	2002	308	109	57	-	3	7	740	3,728	-	13	1	0	71
	2003	308	240	179	-	3	7	740	3,728	-	13	1	0	71
	2004	308	554	165	-	3	7	740	3,728	-	13	1	0	71
	2005	308	1,135	187	-	3	7	740	3,728	-	13	1	0	71
	2006	308	1,429	161	-	3	7	740	3,728	-	13	1	0	71
	2007	313	1,896	386	-	3	7	740	3,728	-	13	1	0	71
	2008	244	349	53	8	3	1	571	1,853	-	-	1	-	21
	2009	982	977	166	22	3	1	571	1,860	-	-	1	-	21
	2010	856	648	187	23	3	1	571	1,853	-	-	1	-	21
	2011	497	528	148	1	3	1	571	1,853	-	-	1	-	21
	2012	642	526	450	41	3	1	571	1,853	-	-	1	-	21
	2013	381	714	284	73	-	-	96	485	-	-	0	-	9
	2014	217	456	1,298	109	-	-	96	485	-	-	0	-	9
	2015	433	643	337	102	-	-	96	485	-	-	0	-	9
	2016	365	565	514	98	-	-	96	485	-	-	0	-	9
	2017	200	689	823	56	2	-	57	158	-	1	1	1	1
	2018	75	265	664	163	2	-	57	158	-	1	1	1	1
	2019	252	366	708	42	2	-	57	158	-	1	1	1	1
	2020	190	390	570	80	2	-	57	158	-	1	1	1	1
	2021	173	318	450	28	2	-	25	108	-	1	1	-	1
	2022	173	51	546	28	2	-	25	108	-	1	1	-	1
	2023	173	61	399	28	2	-	25	108	-	1	1	-	1

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
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
	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	304	25	10	-	21	1	45
	2009	5	3	-	-	69	3	295	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	295	25	10	-	21	1	45
	2013	-	45	5	-	22	2	179	79	8	-	20	-	32
	2014	-	34	-	-	22	2	165	79	8	-	20	-	32
	2015	1	1	0	-	22	2	181	79	8	-	20	-	32

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	2	9	-	-	23	2	177	79	8	-	20	-	32
	2017	2	-	-	-	23	0	96	29	23	-	31	1	117
	2018	-	-	-	-	23	5	121	31	23	-	31	1	127
	2019	1	-	-	-	23	0	113	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
	2023	-	-	-	-	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
	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

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
	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	-	5	8	-	1	-	6	2	20	-	-	-	-
	2015	-	13	-	-	1	-	6	2	20	-	-	-	-
	2016	-	18	3	-	1	-	6	2	20	-	-	-	-
	2017	-	0	4	-	7	-	9	2	5	0	-	-	-
	2018	-	2	0	-	7	-	9	2	5	0	-	-	-
	2019	-	1	2	-	7	-	9	2	5	0	-	-	-
	2020	-	2	-	-	7	-	9	2	7	0	-	-	-
	2021	-	-	-	-	5	-	3	2	5	0	-	-	-
	2022	-	-	-	-	5	-	3	2	5	0	-	-	-
	2023	-	-	-	-	5	-	3	2	5	0	-	-	-
Settlements	1990	22	-	-	-	30	48	869	106	41	0	2	-	11
	1991	22	-	-	-	30	48	869	106	41	0	2	-	11
	1992	22	-	-	-	30	48	869	106	41	0	2	-	11
	1993	22	-	-	-	30	48	869	106	41	0	2	-	11
	1994	22	-	-	-	30	48	869	106	41	0	2	-	11
	1995	22	-	-	-	30	48	869	106	41	0	2	-	11
	1996	22	-	-	-	30	48	869	106	41	0	2	-	11
	1997	22	-	-	-	30	48	869	106	41	0	2	-	11
	1998	22	-	-	-	30	48	869	106	41	0	2	-	11
	1999	22	-	-	-	30	48	869	106	41	0	2	-	11

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	22	20	-	-	30	48	869	106	41	0	2	-	11
	2001	22	19	-	-	30	48	869	106	41	0	2	-	11
	2002	22	13	9	-	30	48	869	106	41	0	2	-	11
	2003	22	28	27	-	30	48	869	106	41	0	2	-	11
	2004	22	64	25	-	30	48	869	106	41	0	2	-	11
	2005	22	131	28	-	30	48	869	106	41	0	2	-	11
	2006	22	165	24	-	30	48	869	106	41	0	2	-	11
	2007	22	220	58	-	30	48	869	106	41	0	2	-	11
	2008	11	5	1	-	51	26	553	60	19	0	0	-	18
	2009	13	18	7	-	51	26	553	60	19	0	0	-	18
	2010	14	16	8	-	51	26	553	60	19	0	0	-	18
	2011	0	39	7	-	51	26	553	60	19	0	0	-	18
	2012	7	26	7	0	51	26	553	60	19	0	0	-	18
	2013	8	8	7	-	82	51	1,042	80	41	2	1	-	13
	2014	2	20	4	-	82	51	1,042	80	41	2	1	-	13
	2015	19	17	3	2	82	51	1,044	80	41	2	1	-	13
	2016	22	29	15	8	82	51	1,042	80	41	2	1	-	13
	2017	7	9	-	2	87	29	634	24	33	0	0	-	5
	2018	5	4	5	-	87	29	706	24	35	0	0	-	5
	2019	8	6	3	0	90	29	645	24	36	0	0	-	5
	2020	14	10	8	-	86	29	635	24	33	0	0	-	5
	2021	9	6	3	0	77	23	602	23	24	0	0	-	4
	2022	9	1	4	0	77	23	602	23	24	0	0	-	4
	2023	9	1	3	0	77	23	602	23	24	0	0	-	4

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
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	8	5	-	0	1	41	89	18	2	3	0	-
	2003	22	19	16	-	0	1	41	89	18	2	3	0	-
	2004	22	43	15	-	0	1	41	89	18	2	3	0	-
	2005	22	88	17	-	0	1	41	89	18	2	3	0	-
	2006	22	111	14	-	0	1	41	89	18	2	3	0	-
	2007	22	148	34	-	0	1	41	89	18	2	3	0	-
	2008	15	10	-	-	1	0	121	137	58	16	7	-	-
	2009	82	46	13	-	1	0	121	137	58	16	7	-	-
	2010	119	33	7	2	1	0	121	137	58	16	7	-	-
	2011	133	74	8	-	1	0	121	137	58	16	7	-	-
	2012	139	56	11	-	1	0	121	137	58	16	7	-	-
	2013	102	84	25	-	1	0	40	90	80	12	20	-	-
	2014	61	96	23	-	1	0	40	90	80	12	20	-	-
	2015	92	151	2	-	1	0	40	90	80	12	20	-	-

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	61	154	108	-	1	0	40	90	80	12	20	-	-
	2017	17	26	40	-	-	-	16	25	73	5	1	0	-
	2018	34	22	23	-	-	-	15	23	73	5	1	0	-
	2019	41	14	19	-	-	-	15	23	73	5	1	0	-
	2020	43	12	3	-	-	-	15	23	75	5	1	0	-
	2021	40	16	9	1	-	-	11	20	62	2	1	0	-
	2022	40	3	11	1	-	-	11	20	62	2	1	0	-
	2023	40	3	8	1	-	-	11	20	62	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. Table A5.2.7 shows the area of mineral and organic soil per land use, with organic soils categorised as ‘cold’ or ‘warm’ according to climate zones.

Table A5.2.7 Land use by mineral and organic soil for 2023

Category	Land use	Area (kha)		
		Mineral	Organic cold	Organic warm
Forest land	Pre-1990 natural forest	7,733.2	5.8	5.0
	Pre-1990 planted forest	1,431.9	0.2	1.8
	Post-1989 planted forest	881.7	0.8	0.9
	Post-1989 natural forest	111.5	0.0	0.0
Cropland	Annual	381.8	0.0	7.3
	Perennial	105.3	0.0	2.8
Grassland	High producing	6,589.2	9.3	138.2
	Low producing	6,240.8	5.9	6.0
	With woody biomass	1,336.3	5.0	2.6
Wetlands	Open water	533.4	1.7	2.5
	Vegetated	183.3	11.8	48.8
Settlements	Settlements	240.5	0.0	2.9
Other land	Other land	896.7	0.2	0.1
Total		26,665.6	40.7	218.8

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:

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

Where: ΔC = change in carbon stocks (tonnes)

SOC_0 = stable SOC stock in the inventory year (tonnes C ha⁻¹)

$SOC_{(0-T)}$ = 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 (McNeill et al., 2014).

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 $C_{i,j}^{0-30\text{cm}}$ in land use category i and soil–climate class j as:

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

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 then 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).

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).

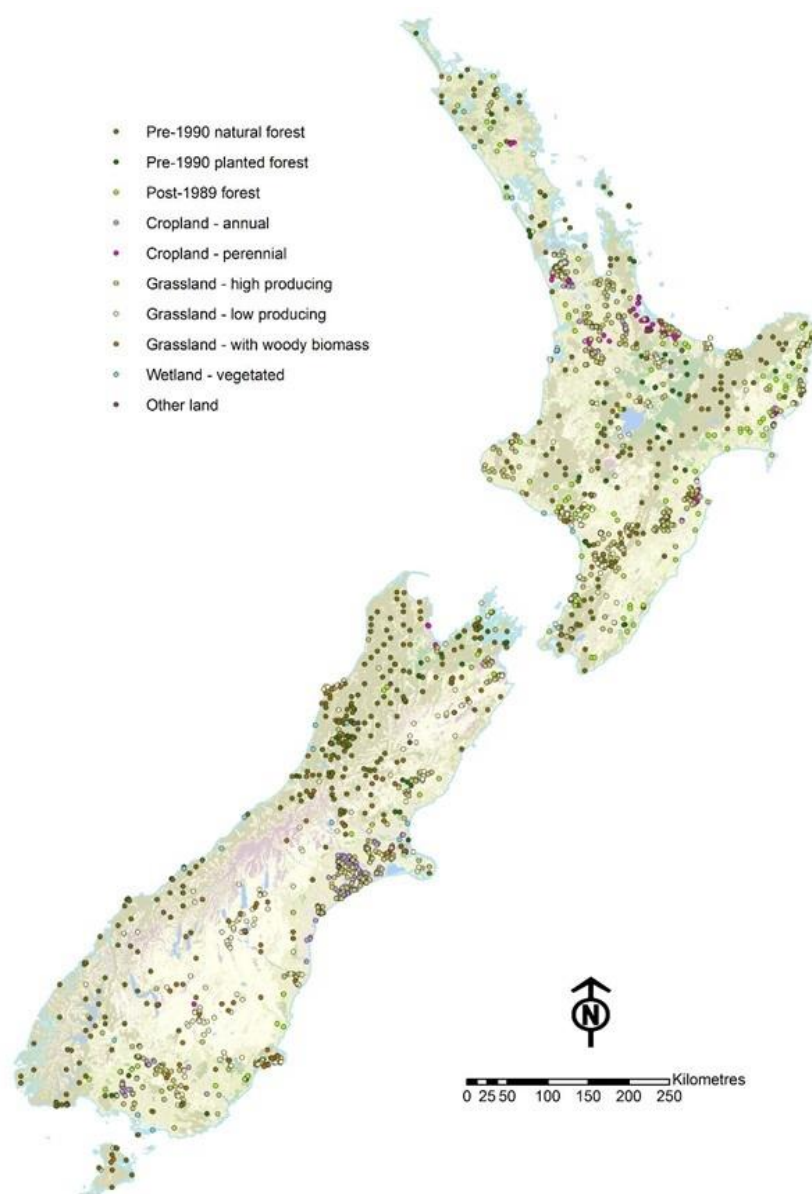
Together, the five combined data sets cover most of New Zealand, including Stewart Island (figure A5.2.8). Coverage does not extend to the Chatham Islands and other offshore islands. In addition to soil data, each record contains the site-specific climate, slope and rainfall attributes that are used 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.

⁷ Manaaki Whenua – Landcare Research. [National Soils Database](#). Retrieved 14 March 2025.

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 low 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 Layer⁸ 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 A5.2.8). Steady state SOC stocks for each land use (table A5.2.9) 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 A5.2.8). 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 A5.2.8 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 Manaaki Whenua – Landcare Research. *Maps of Fundamental Soil Layers*. Retrieved 14 March 2025.

Table A5.2.9 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:

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

Where: $\text{Var}(L_i)$ = the variance of land use effect i

$\text{Cov}(L_i, L_j)$ = the covariance between land use effects L_i and L_j (McNeill and Barringer, unpublished; McNeill et al., 2014).

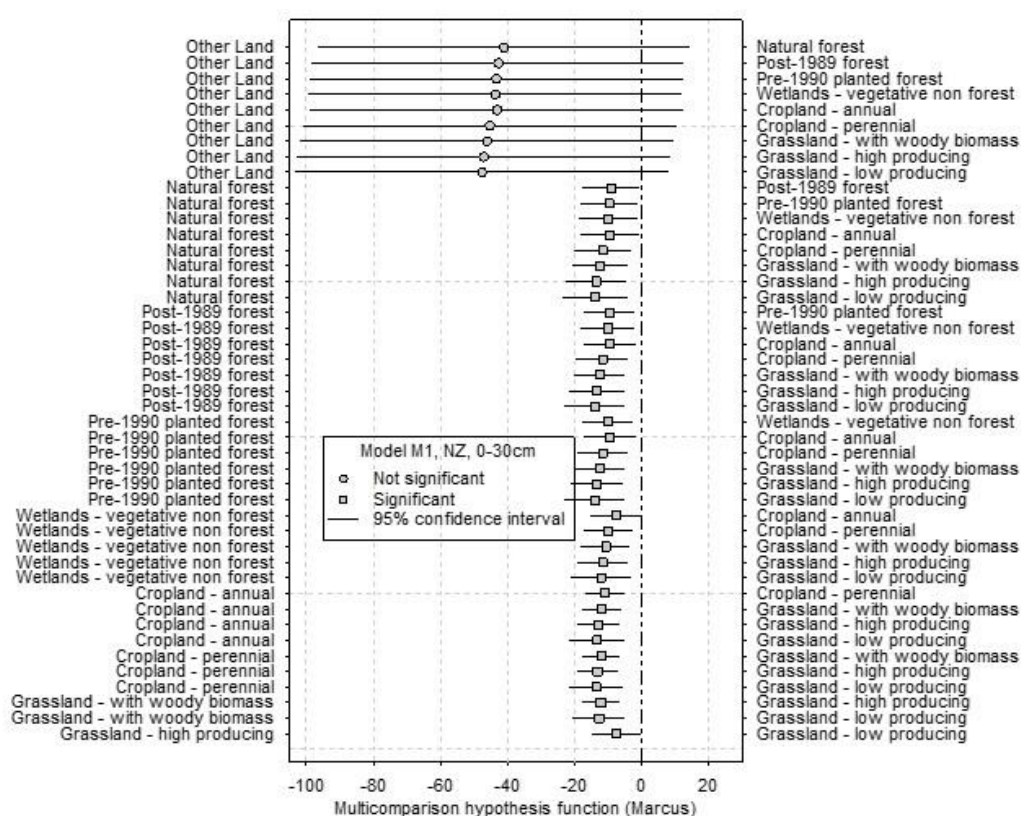
Although equation A5.2.3 provides a mathematically straightforward way to estimate the significance of a single transition from one land use category to another (a comparison-wise significance), it is often desirable to be able to determine whether a number of land use categories are likely to be significantly 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 A5.2.9) 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 A5.2.10). 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 A5.2.10 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	5.0 ± 90%	IPCC (2006b, section 5.2.3.2, table 5.6)
	Warm temperate	10.0 ± 90%	
Grassland	Cold temperate	0.25 ± 90%	IPCC (2006b, section 6.2.3.2, table 6.3)
	Warm temperate	2.5 ± 90%	
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	5.0 ± 90%	Cropland emission factors used (IPCC, 2006b, section 8.2.3.2)
	Warm temperate	10.0 ± 90%	
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, 2024a) 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, 2024a), which comprise a higher proportion of the post-1989 planted forest estate.
2. Total destocking area between 2013 and 2023 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, 2024b).

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, 2024b).

Deforestation area

1. Deforestation area from 1990 to 2020, for all forest types, is based on mapping data.
2. Deforestation area for 2021 to 2023, 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, 2024) (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 affect the total destocking estimate.
5. The harvest area of pre-1990 planted forest is then calculated for 1990 to 2023 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 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 and deforestation 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 A5.2.20 to A5.2.22) 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 the entire planted forest estate. 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, 2024a). 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. 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, 2024a). 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).

Table A5.2.11 demonstrates the destocking age profile for all planted forest expressed as a percentage for the ages 15–45 years. Note that a small proportion of destocking occurs before the age of 15 years (not shown in table A5.2.11). This predominately relates to post-1989 destocking that occurs prior to 2008.

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 2023 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 constrained. This results in no harvesting occurring in specific age classes, which presents as a bi-modal distribution in the harvest age profile.

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, 2024b).

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.

Table A5.2.11 Proportion of total destocking area by age across all planted forest, 1990–2023

Year	Destocking age by 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
2023	1.2	1.1	0.8	1.0	1.3	1.3	1.1	1.4	1.6	2.8	7.1	11.7	14.0	13.4	11.4	9.3	7.5	0.3	0.2	0.0	0.0	0.0	1.5	1.3	2.7	2.8	1.6	1.2	0.0	0.3	0.3
2022	1.1	1.1	1.2	1.1	1.3	1.3	1.1	1.4	1.6	2.7	7.1	11.6	13.9	13.3	11.5	11.6	0.5	0.3	0.0	0.0	0.1	2.5	2.1	3.5	3.5	2.2	1.7	0.0	0.3	0.3	0.3
2021	0.9	1.7	1.0	0.8	1.4	1.1	1.4	0.9	1.9	1.6	5.0	10.3	13.4	14.1	17.1	0.9	0.4	0.0	0.0	2.7	3.7	3.3	5.1	4.7	3.0	2.3	0.1	0.2	0.3	0.3	0.2
2020	2.3	1.1	0.9	0.9	1.3	1.1	1.3	1.0	1.7	1.8	5.3	10.1	12.9	13.1	1.5	1.2	5.2	2.9	4.6	5.0	4.3	6.3	6.0	3.7	2.8	0.1	0.5	0.3	0.2	0.3	0.2
2019	0.2	1.2	0.9	0.8	1.3	1.0	1.3	0.9	1.7	1.6	4.9	9.8	12.7	5.2	0.9	10.2	8.0	7.8	7.7	6.0	2.8	2.3	4.9	3.6	0.1	0.6	0.5	0.3	0.3	0.3	0.2
2018	0.4	1.3	0.9	1.0	1.4	1.2	1.3	1.1	1.9	2.1	6.3	11.6	13.0	6.0	11.5	9.8	7.6	6.0	4.3	2.9	2.3	2.0	1.6	0.1	0.6	0.5	0.5	0.2	0.2	0.3	0.2
2017	0.2	1.7	1.3	1.0	2.0	1.3	1.9	1.0	2.7	1.8	6.9	9.7	12.5	12.6	10.4	8.2	6.4	5.2	3.7	2.4	1.9	1.7	0.5	0.6	0.6	0.5	0.5	0.2	0.2	0.2	0.2
2016	0.5	1.3	1.0	1.1	1.5	1.3	1.4	1.4	1.9	2.5	5.2	9.5	11.7	11.6	10.8	9.0	7.3	6.0	3.7	2.6	2.0	1.9	1.2	0.8	0.7	0.6	0.4	0.2	0.2	0.2	0.2
2015	0.4	1.2	1.0	1.0	1.8	1.2	1.5	1.2	1.7	1.8	4.8	9.5	10.9	12.3	11.0	9.3	7.5	5.7	4.2	2.9	2.4	1.7	1.5	0.9	0.8	0.6	0.5	0.2	0.3	0.3	0.2
2014	0.8	1.0	1.0	1.2	1.3	1.3	0.9	1.5	1.2	2.9	7.6	10.6	11.6	11.9	10.3	8.3	6.7	5.1	3.6	2.9	1.8	1.8	1.2	1.0	0.6	0.6	0.3	0.3	0.3	0.2	0.3
2013	1.1	1.5	1.2	1.4	1.3	1.4	1.2	1.2	1.3	3.0	6.9	9.0	12.0	11.9	10.3	8.5	6.6	5.2	4.3	2.0	2.1	1.8	1.5	0.8	0.6	0.5	0.4	0.3	0.3	0.2	0.3
2012	0.9	1.0	0.8	1.2	1.1	1.3	0.8	1.5	1.4	3.2	6.8	10.1	12.4	11.7	10.5	8.3	6.9	6.0	3.6	2.2	2.1	2.0	1.1	0.8	0.5	0.6	0.4	0.3	0.3	0.2	0.3
2011	1.5	1.0	0.8	1.0	1.2	1.1	1.0	1.3	1.4	2.5	6.1	9.4	12.2	12.4	10.3	8.8	7.5	5.3	3.6	2.6	2.2	1.8	1.3	0.8	0.7	0.6	0.4	0.3	0.3	0.3	0.3
2010	0.7	1.0	0.8	1.1	1.1	1.1	1.1	1.4	1.3	2.8	6.0	11.0	13.1	12.0	9.9	8.8	6.8	5.1	3.6	2.6	2.1	1.8	1.1	0.9	0.7	0.6	0.4	0.3	0.3	0.3	0.3
2009	1.0	1.0	0.8	1.2	1.0	1.4	0.8	1.6	1.2	3.4	8.0	11.5	13.0	11.6	9.9	7.9	6.3	4.7	3.2	2.4	2.0	1.5	1.1	0.8	0.6	0.6	0.3	0.3	0.3	0.2	0.3
2008	1.1	1.0	0.7	1.2	1.1	1.3	0.8	1.7	1.2	3.7	8.6	11.8	13.1	11.4	9.7	7.6	6.2	4.6	3.1	2.3	1.9	1.6	1.0	0.8	0.6	0.6	0.3	0.3	0.3	0.2	0.3
2007	3.1	3.4	2.4	1.2	0.9	1.2	0.7	1.0	1.6	3.5	7.7	10.6	11.7	10.2	12.5	6.8	3.6	6.0	2.8	2.1	1.0	1.6	1.2	0.8	0.6	0.5	0.4	0.2	0.2	0.3	0.2
2006	2.1	1.6	0.7	1.2	0.9	1.2	0.8	1.6	1.2	3.7	8.2	11.3	12.4	10.8	12.2	7.2	5.9	4.4	2.9	1.5	2.0	1.7	1.1	0.8	0.6	0.6	0.4	0.3	0.3	0.2	0.3
2005	2.4	0.9	0.8	1.2	1.0	1.2	0.9	1.5	1.6	4.5	8.8	11.6	12.2	10.6	11.6	7.1	5.7	4.2	2.0	2.4	1.9	1.6	1.1	0.8	0.6	0.5	0.3	0.3	0.2	0.2	0.3
2004	1.0	0.8	1.0	1.1	1.1	1.0	1.2	1.4	2.4	6.1	10.1	12.3	12.1	10.4	9.9	6.9	5.4	3.3	2.8	2.2	1.9	1.4	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.3	0.3
2003	1.0	0.8	1.1	1.1	1.2	0.9	1.4	1.3	2.9	6.9	10.7	12.6	11.9	10.2	8.8	6.7	4.9	3.7	2.6	2.1	1.8	1.2	0.9	0.7	0.6	0.4	0.3	0.3	0.3	0.3	0.3
2002	1.0	0.7	1.2	1.0	1.3	0.8	1.6	1.2	3.4	7.9	11.4	13.0	11.6	9.9	8.2	6.4	4.8	3.4	2.5	2.1	1.7	1.1	0.8	0.6	0.6	0.3	0.3	0.3	0.2	0.3	0.3
2001	1.0	0.7	1.3	1.0	1.4	0.7	1.8	1.1	3.8	8.7	12.0	13.2	11.4	9.6	7.8	6.2	4.7	3.1	2.3	2.0	1.8	0.9	0.8	0.6	0.6	0.3	0.3	0.3	0.2	0.3	0.3
2000	0.9	0.7	1.4	0.9	1.4	0.7	1.9	1.1	4.1	9.2	12.3	13.3	11.2	9.1	7.9	6.1	4.5	3.0	2.3	1.9	1.7	1.0	0.8	0.6	0.6	0.3	0.3	0.3	0.2	0.3	0.3
1999	1.0	0.8	1.1	1.1	1.2	0.9	1.4	1.3	2.9	7.1	10.9	12.7	11.9	10.2	8.5	6.7	5.1	3.6	2.6	2.1	1.8	1.2	0.9	0.7	0.6	0.4	0.3	0.3	0.3	0.3	0.3
1998	1.0	0.9	0.9	1.2	1.1	1.1	1.1	1.5	2.1	5.5	9.7	12.3	12.4	10.9	9.0	7.1	5.6	4.1	2.8	2.2	1.9	1.4	0.9	0.7	0.6	0.5	0.3	0.3	0.3	0.3	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
1997	1.1	0.9	0.9	1.2	1.1	1.2	1.0	1.6	1.8	5.0	9.4	12.1	12.6	10.9	9.4	7.3	5.8	4.2	2.9	2.2	1.9	1.5	0.9	0.7	0.6	0.5	0.3	0.3	0.3	0.3	0.3
1996	1.1	0.9	0.8	1.2	1.1	1.2	1.0	1.6	1.8	4.8	9.3	12.1	12.6	11.0	9.4	7.3	5.8	4.3	2.9	2.3	1.9	1.5	0.9	0.7	0.6	0.5	0.3	0.3	0.3	0.2	0.3
1995	1.1	0.9	0.8	1.2	1.0	1.2	1.0	1.6	1.7	4.7	9.2	12.0	12.7	10.7	9.8	7.3	5.9	4.3	2.9	2.3	1.9	1.5	0.9	0.8	0.6	0.5	0.3	0.3	0.3	0.2	0.3
1994	1.1	0.9	0.8	1.3	1.0	1.3	0.9	1.6	1.4	4.2	8.8	11.9	12.8	11.1	9.8	7.5	6.0	4.5	3.0	2.3	1.9	1.6	1.0	0.8	0.6	0.6	0.3	0.3	0.3	0.2	0.3
1993	1.1	0.9	0.8	1.3	1.0	1.3	0.9	1.6	1.4	4.2	8.8	11.9	12.8	10.7	10.2	7.5	6.0	4.5	3.0	2.3	1.9	1.6	1.0	0.8	0.6	0.6	0.3	0.3	0.3	0.2	0.3
1992	1.1	0.9	0.8	1.3	1.0	1.3	0.9	1.6	1.4	4.2	8.8	11.9	12.8	10.8	10.1	7.5	6.0	4.5	3.0	2.3	1.9	1.6	1.0	0.8	0.6	0.6	0.3	0.3	0.3	0.2	0.3
1991	1.1	0.9	0.8	1.3	1.0	1.3	0.9	1.6	1.4	4.2	8.8	11.9	12.8	8.5	12.4	7.5	6.0	4.5	3.0	2.3	1.9	1.6	1.0	0.8	0.6	0.6	0.3	0.3	0.3	0.2	0.3
1990	1.1	0.9	0.8	1.3	1.0	1.3	0.9	1.6	1.4	4.2	8.8	11.9	12.8	8.5	12.5	7.5	6.0	4.5	3.0	2.3	1.9	1.6	1.0	0.8	0.6	0.6	0.3	0.3	0.3	0.2	0.3

Figure A5.2.10 Harvest area by age for pre-1990 planted forest in 2023

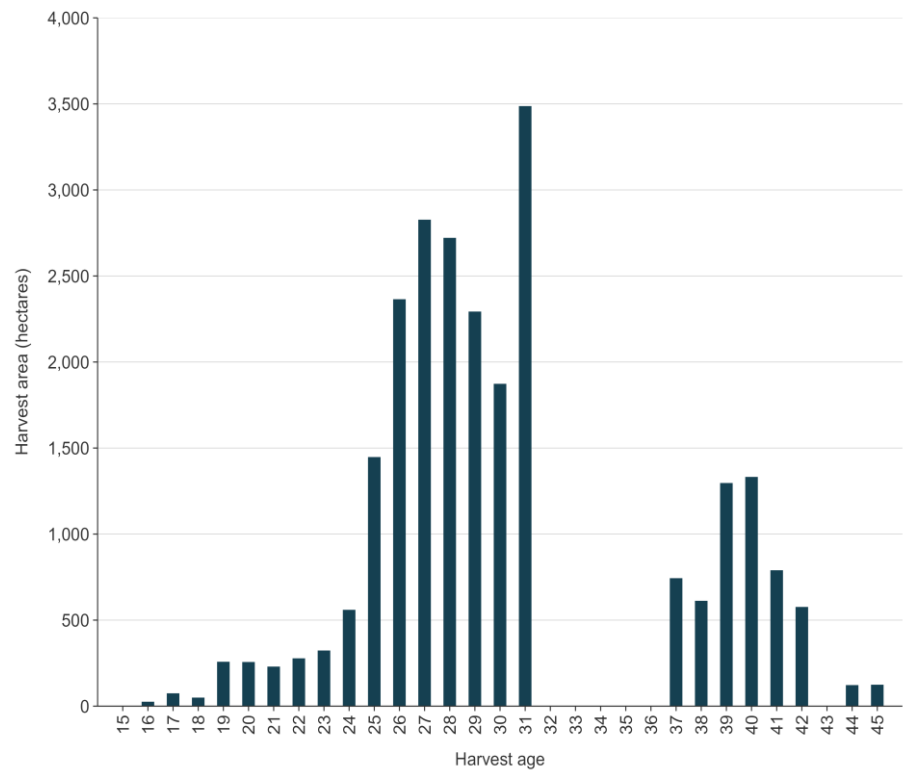
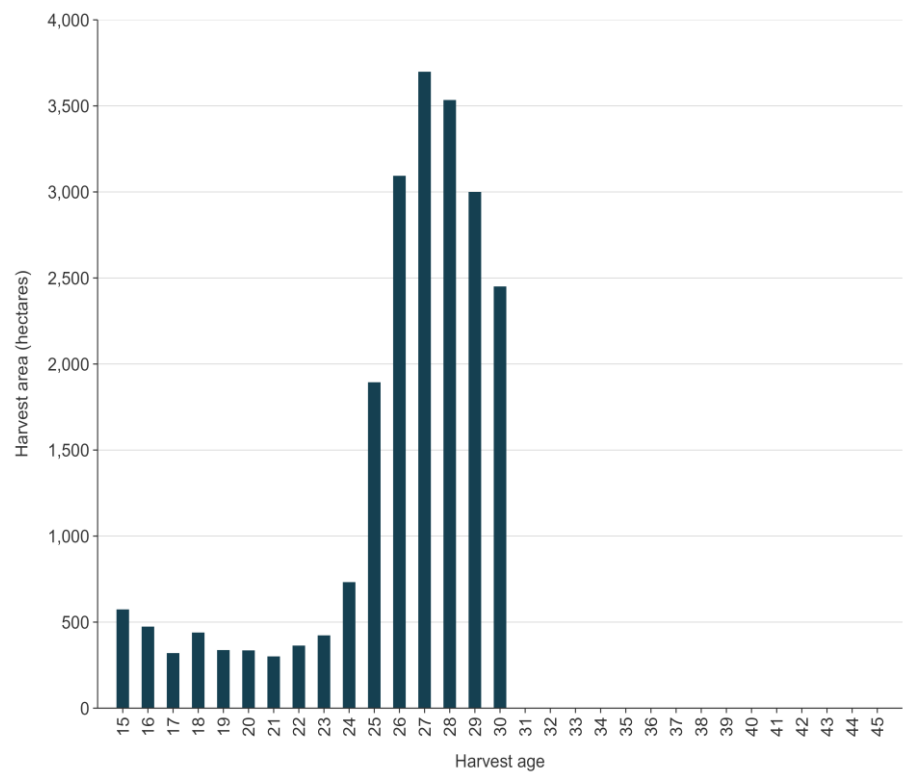


Figure A5.2.11 Harvest area by age for post-1989 planted forest in 2023



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. Measurements for this third round were carried out from 2014 to 2024 and will be incorporated into future submissions upon completion of analysis. 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 A5.2.12 summarises the method used to calculate the carbon stock in each biomass pool from the information collected at each plot.

Table A5.2.12 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	Easdale et al., 2019; Paul et al., 2021
Dead organic matter	Dead wood	Modelled from plot measurements; allometric equations	Garrett et al., 2019; Kimberley et al., 2019; Paul et al., 2021
	Litter	Plot samples; laboratory analysis of samples collected at plots	Garrett, unpublished; Paul et al., 2021

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); or
- c) 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 A5.2.13.

Table A5.2.13 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 complete and will be incorporated into future submissions upon completion of analysis). 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 5.0.⁹ 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 $\text{C ha}^{-1} \text{yr}^{-1}$ (estimated from Paul et al., 2021). The tall forest component changed very little over the same period (-0.01 ± 0.19 tonnes $\text{C ha}^{-1} \text{yr}^{-1}$). 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 $\text{C ha}^{-1} \text{yr}^{-1}$; 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 $\text{C ha}^{-1} \text{yr}^{-1}$ (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 $\text{C ha}^{-1} \text{yr}^{-1}$.

⁹ Manaaki Whenua – Landcare Research. *LCDB v5.0 Land Cover Database version 5.0, Mainland New Zealand*. Retrieved 11 November 2021.

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).

The Land Cover Database version 5.0 is used to align the plot-based carbon stock analysis with the mapped area of each forest class (i.e., ‘tall’ or ‘regenerating’). This method has been used since the 2022 submission. Prior to the 2022 submission, pre-1990 tall and regenerating forest plots were classified using species composition (Wiser, 2016), but this created a mismatch where carbon stock change estimates of these forest classes were not consistent with the forest area they were intended to represent.

Post-1989 natural forest

Estimates of carbon stock and stock change in post-1989 natural forest were 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 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 A5.2.19). 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* (Douglas fir). 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* (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 A5.2.14.

Table A5.2.14 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)	(% 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(e)).

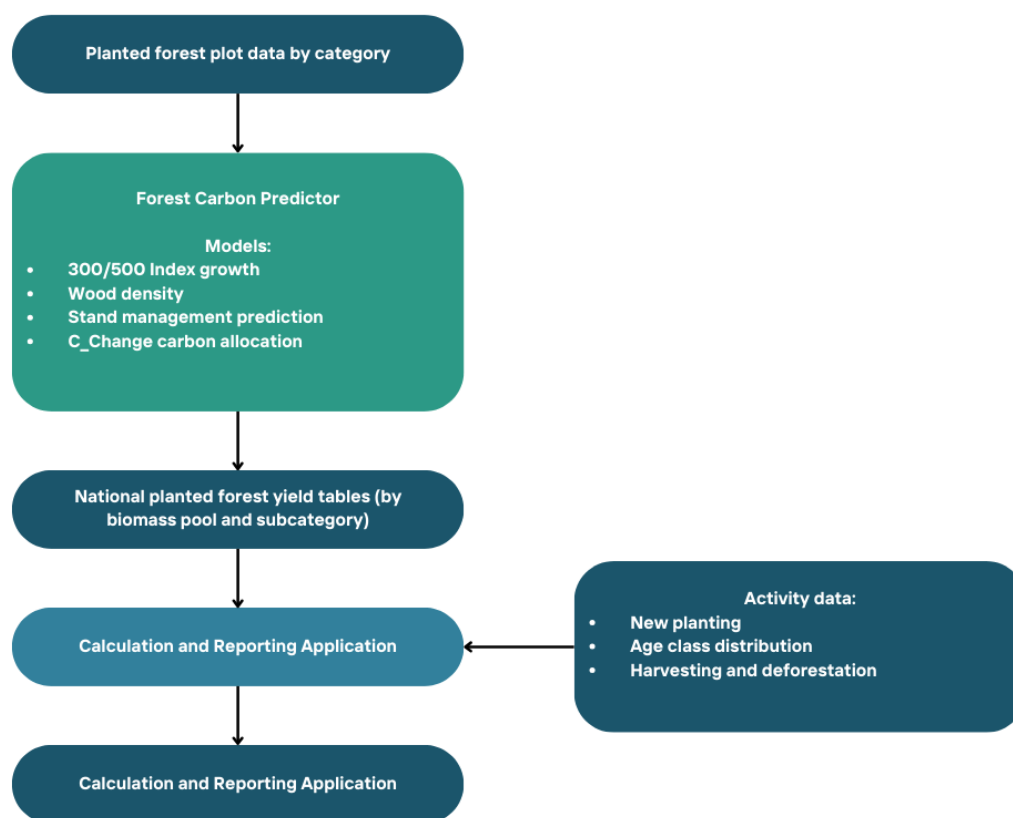
Below-ground biomass is derived from the above-ground biomass estimates. For plantation crop trees, below-ground biomass is assumed to be 15 per cent to 20 per cent of total production, depending on stand age (Beets et al., 1999). The ratio for non-crop trees and shrubs is 25 per cent (Coomes et al.,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



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).

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 yield tables are based on: the full first annual inventory cycle from 2016 to 2020, prior periodic inventories since 2007, and 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., 2024).

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 et al., 2024). 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; Moore and Goulding, unpublished); checking eligibility of plots; independent audits of field plot measurements (e.g., Beets and Holt, unpublished); auditing data entry; and data processing and modelling (Woollens, unpublished). These activities are described in detail below.

Pre-1990 natural forest

During the initial measurement of the natural forest plot network (2002 to 2007), 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, 2024b) (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* model (0.21 tonnes C m⁻³ for coniferous and 0.25 tonnes C m⁻³ for non-coniferous timber).

The results show alignment between the two data sources from 2013 to 2023. 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, 2024b) 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 2023



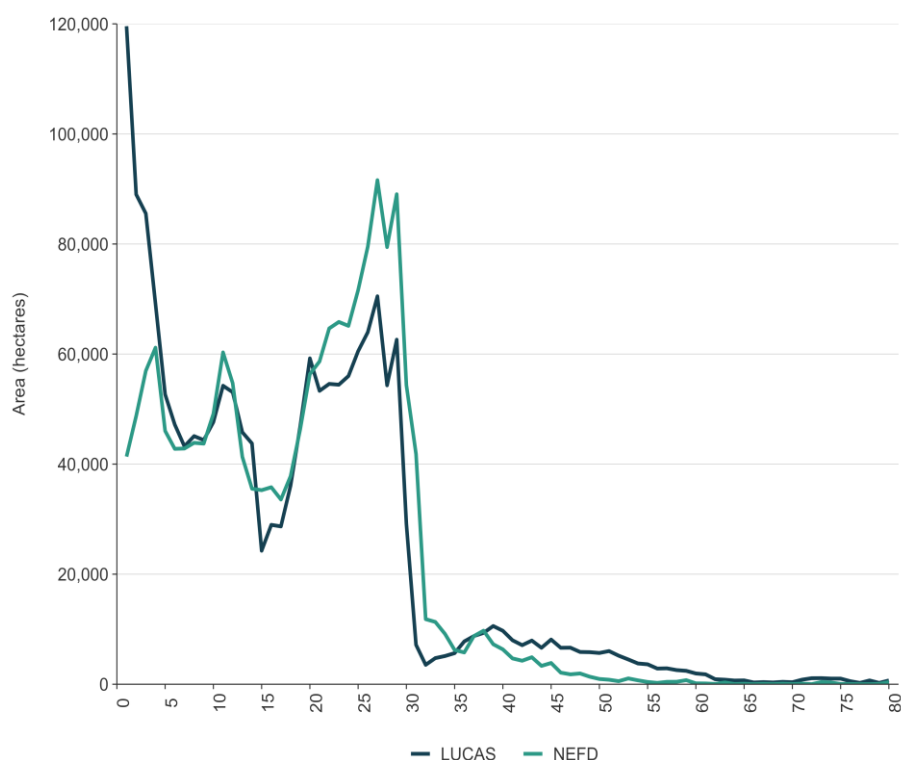
Note: MPI Roundwood = roundwood production data sourced from Ministry for Primary Industries (2024b).
LUCAS = Land Use and Carbon Analysis System.

Planted forest age profile

The LUCAS net stocked area planted forest age profile at the end of the simulation in 2023 was compared with the NEFD planted forest age profile (Ministry for Primary Industries, 2024a) (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 2023 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 33.
2. The LUCAS pre-1990 planted forest age profile from ages 0 to 33 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 34 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 2023



Note: The age profile starts at age 1 and does not include areas of forest that were planted or harvested and awaiting replanting in 2023. 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 and 2023 NIR submissions, 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 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 is presented here following the 2024 NIR submission, using data from the 2018 to 2022 forest inventory (table A5.2.15 and figures A5.2.15 to A5.2.17).

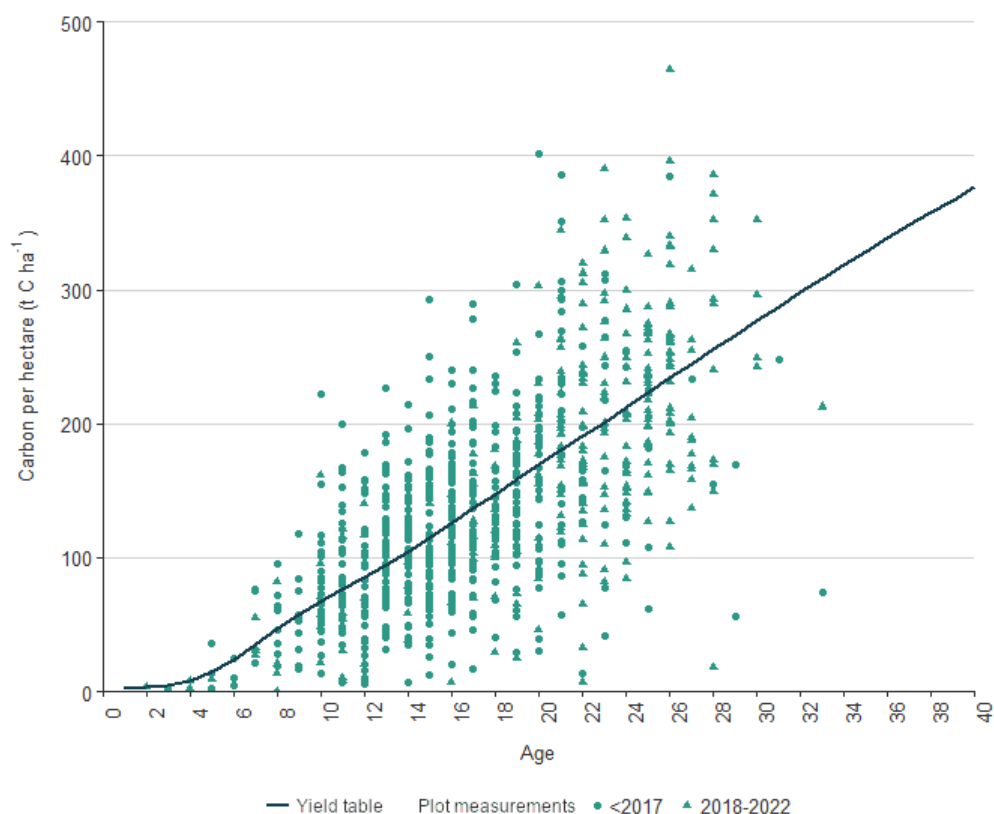
An area-weighted average carbon stock per hectare for each forest type was calculated from plots measured in the 2018 to 2022 planted forest inventory and from adjusted yield table values fitted to the ages of these plots (table A5.2.15). Note that because the Forest Carbon Predictor generates yield 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. (2024), because these estimates only include plots used to generate the yield tables.

Table A5.2.15 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

Forest type	Plots measured in 2018–22 forest inventory			Yield table fitted to plot age		
	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 A5.2.15). 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.

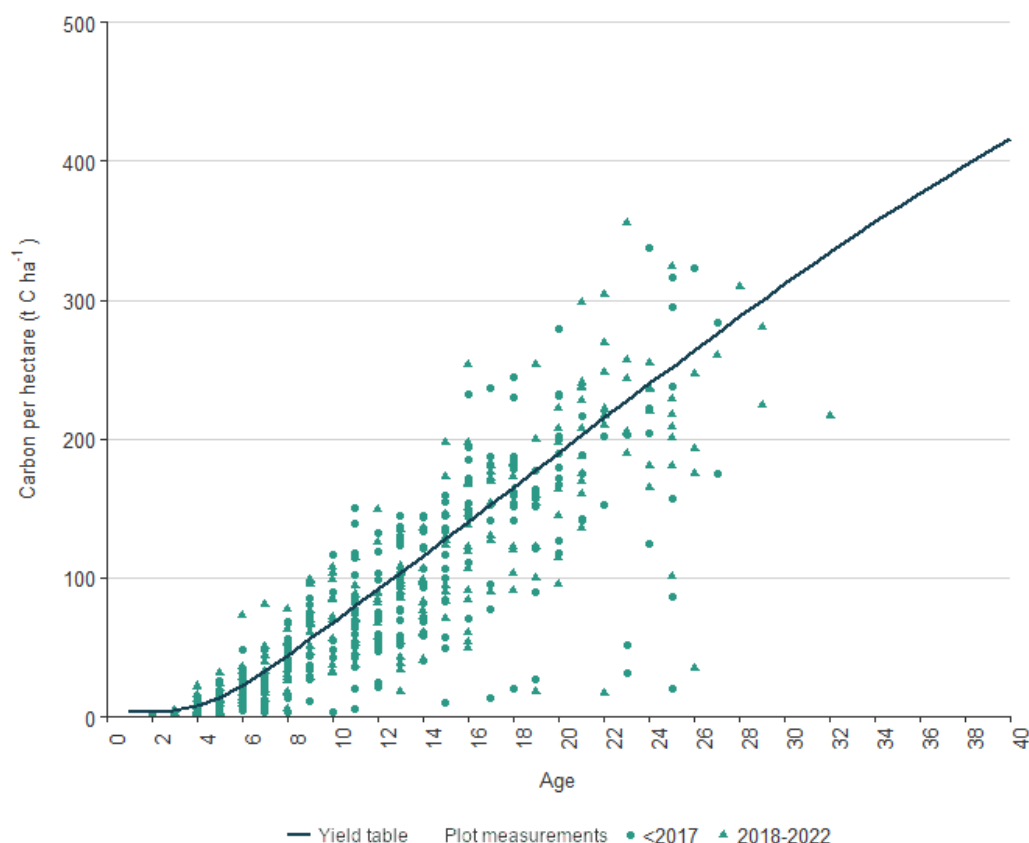
Figure A5.2.15 Carbon stock by age for post-1989 planted forest estimated from the yield table and forest inventory plots



Note: Solid black line – yield table. Circles – plots measured in 2017 or earlier. Triangles – plots measured from 2018 to 2022.

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 years and 26 years 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 from 2018 to 2022.

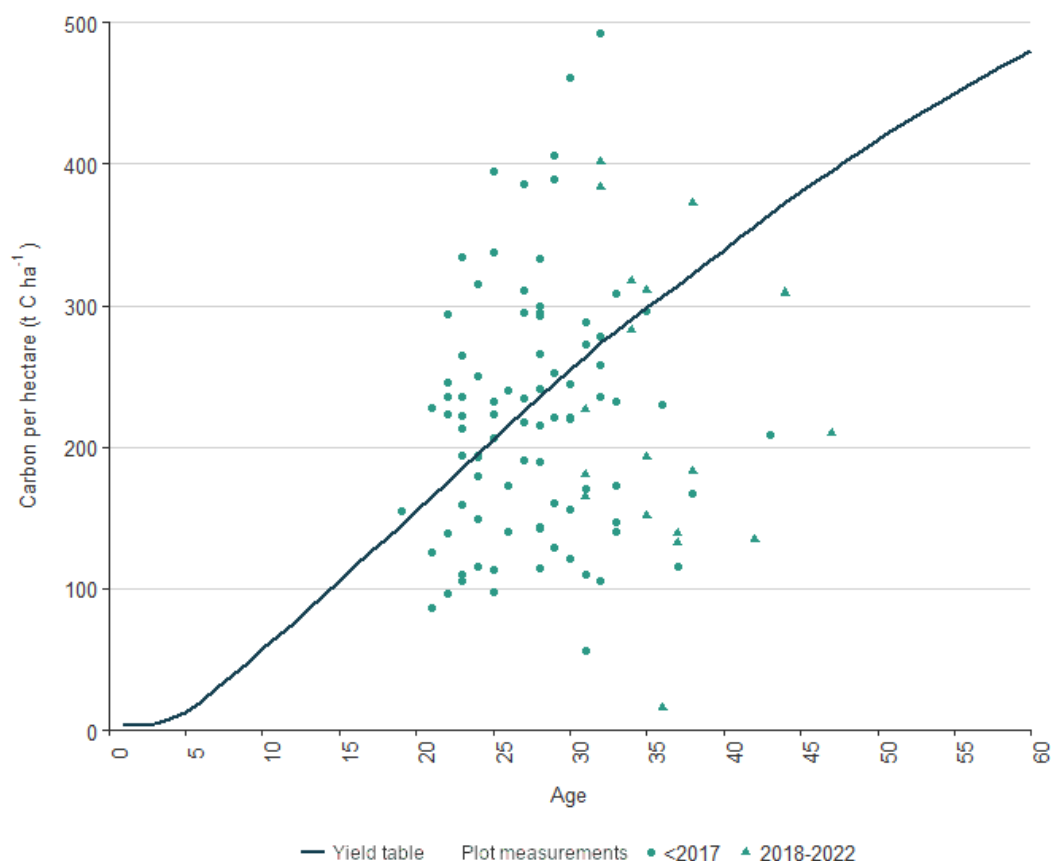
The average carbon stock per hectare of measured plots in pre-1990 forest planted before 1990 is 233.6 ± 47.8 tonnes C ha⁻¹. When fitting the adjusted yield table carbon values to the measured plot ages, the average carbon stock per hectare is 309.5 ± 24.0 tonnes C ha⁻¹. On average, the yield table estimates 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



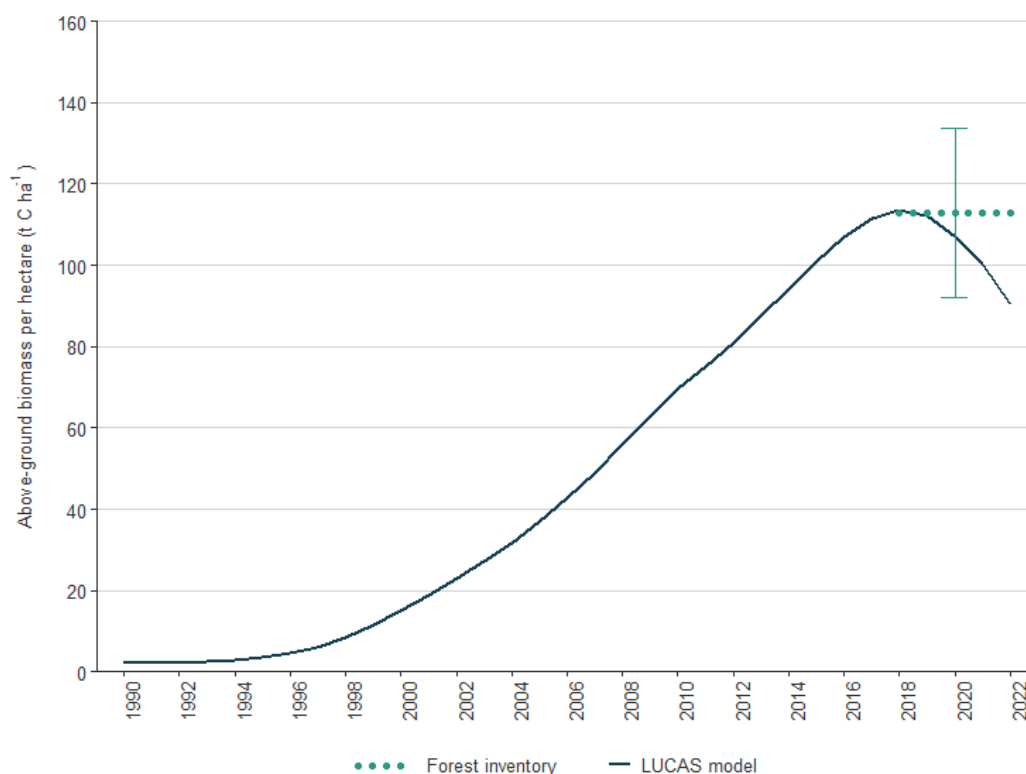
Note: Solid black line – yield table. Circles – plots measured in 2017 or earlier. Triangles – plots measured from 2018 to 2022.

LUCAS planted forest model versus forest inventory measurements

In the 2024 submission, the average above-ground biomass carbon stock per hectare, estimated from the planted forest inventory (Paul et al., 2024), 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., 2024). This was 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 in the 2024 submission (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 in the 2024 submission



Note: Solid black line – LUCAS Calculation and Reporting Application model. Dotted green line – above-ground biomass carbon per hectare estimated from the 2018 to 2022 forest inventory ($\pm 95\%$ 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., 2024). This was much lower than the estimated carbon stock per hectare in 2020 generated from the LUCAS CRA model used in the 2024 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.

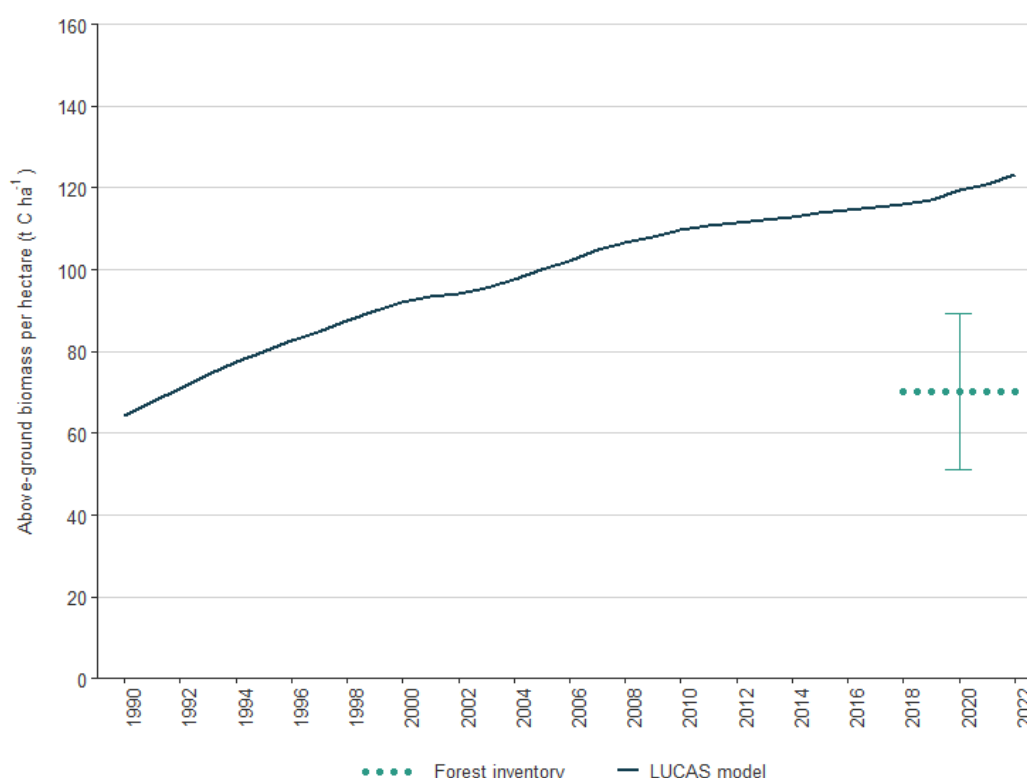
Several factors may contribute to this discrepancy.

1. The carbon stock estimate from the forest inventory (Paul et al., 2024) 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 A5.2.15) 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 (figure A5.2.16 and figure 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. (2024).

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 in the 2024 submission



Note: Solid black line – LUCAS Calculation and Reporting Application model. Dotted green line – above-ground biomass carbon per hectare estimated from the 2018 to 2022 forest inventory ($\pm 95\%$ 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) 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, was a grant scheme 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 provides councils with 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 – New Zealand Forest Service 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 A5.2.16 to A5.2.19).

Table A5.2.16 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
2023	144.6	33.9	44.3	22.2	245.1

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

Table A5.2.17 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

Year	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
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
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
2023	45.9	10.9	10.0	9.7	76.4

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

Table A5.2.18 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

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
17	36.8	9.2	0.1	0.5	46.7
18	39.4	9.9	0.1	0.5	49.9
19	42.0	10.5	0.1	0.5	53.2
20	44.5	11.1	0.1	0.6	56.4
21	47.0	11.8	0.2	0.6	59.5
22	49.4	12.3	0.2	0.6	62.5
23	51.7	12.9	0.2	0.6	65.4
24	53.9	13.5	0.2	0.7	68.2
25	56.0	14.0	0.2	0.7	70.9
26	57.9	14.5	0.2	0.7	73.3
27	59.7	14.9	0.2	0.8	75.6
28	61.4	15.3	0.2	0.8	77.7
29	62.9	15.7	0.2	0.8	79.6
30	64.1	16.0	0.2	0.9	81.3
31	65.2	16.3	0.2	0.9	82.7
32	66.1	16.5	0.2	0.9	83.8
33	66.7	16.7	0.2	1.0	84.6

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

Table A5.2.19 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

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
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
33	66.4	16.6	0.2	0.9	84.1

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 A5.2.20 to A5.2.22).

Table A5.2.20 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

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
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
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 A5.2.21 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

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
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
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 A5.2.22 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
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

Age	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Total biomass
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 (Wakelin, unpublished(i); Wekesa, 2022; Wekesa et al, 2022). Sub-product half-lives and their proportions for each domestic and export market are summarised in tables A5.2.23 and A5.2.24 based on data collected in 2019 and 2021.

Table A5.2.23 *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	Laminated veneer lumber – construction	0.117039	50.3
PANEL	Laminated veneer lumber – formwork	0.02926	1
PAPER	Medium-density fibreboard – floors/ceilings	0.152676	29.1
PANEL	Medium-density fibreboard – other	0.039207	18.2
PANEL	Particle board – 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 A5.2.24 *Harvested wood products type, exported harvested wood products 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	Laminated veneer lumber– construction	0.009467	62.4
PANEL	Laminated veneer lumber – formwork	0.010751	0.7
PAPER	Medium-density fibreboard – floors	0.0461	34.7
PANEL	Medium-density fibreboard – built-ins	0.108038	17.3
PANEL	Medium-density fibreboard – door	0.106167	24.3
PANEL	Medium-density fibreboard – kitchen/bathroom cabinets	0.106167	13.9
PANEL	Medium-density fibreboard – window	0.05961	17.3
PANEL	Medium-density fibreboard – other	0.104753	10.8
PANEL	Particle board – wall/ceilings	0.011299	34.7
PANEL	Particle board – other	0.055395	28.2
SAWN	Construction	0.493773	62.4
SAWN	Outdoor	0.02192	31.6
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 Manley and Evison (2016) and Wakelin and Kimberley (unpublished). Sub-product half-lives and their proportions for each export market are summarised in tables A5.2.25 to A5.2.27 based on data collected in 2015.

Table A5.2.25 *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 m ³)	Half-life
PANEL	Appearance plywood	-	0.1039604	25
PANEL	Construction plywood	Panel (recycled)	1.1435644	2.5
PANEL	-	Burned	1.1435644	0.5
PANEL	Packaging plywood	-	0.2079208	3
-	Plymill residue	Burned	0.0519802	0
PAPER	-	Pulp	0.1559406	2
PANEL	-	Particle board	0.1559406	25
PANEL	-	Medium-density fibreboard	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

Product	Sub-product	Waste/fuel product	Volume (million m ³)	Half-life
PANEL	-	Particle board	0.2079208	25
PANEL	-	Medium-density fibreboard	0.2079208	25
-	Sawdust	Burned	0.1559406	0
-	-	Pellets	0.519802	0
PANEL	-	Particle board	0.1559406	25

Table A5.2.26 *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 m ³)	Half-life
PANEL	Construction plywood	Panel (recycled)	0.1841	25.5
PANEL	-	Burned	0.0526	0.5
PANEL	Appearance plywood	-	0.1052	25
PANEL	Plymill residue	Medium-density fibreboard	0.2104	25
SAWN	Appearance lumber	-	0.0263	35
SAWN	Construction lumber	Particle board	0.6838	25.5
SAWN	-	Burned	0.1841	0.5
SAWN	Packaging lumber	-	0.3682	3
PANEL	Slabwood	Medium-density fibreboard	0.526	25
-	Sawdust	Agriculture	0.1841	0
-	-	Burned	0.0526	0
PANEL	Medium-density fibreboard	-	0.0526	25

Table A5.2.27 *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 (CO₂) 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 emissions is included in the *Land converted to grassland* category. 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 Inventory. 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 (tonnes dry matter 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 is included in the *Grassland remaining grassland* (*Grassland with woody biomass*) category. The activity data are sourced from Stats NZ's APS. The activity data are combined with an emission factor derived from the national vegetation plot network to estimate non-CO₂ 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 estimating wildfire and controlled burning emissions in *Grassland with woody biomass*. 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 CO₂ 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 2023 are estimated to be 76.4 ± 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 per cent and ± 21 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 ± 119.5 per cent and $\pm 1,678.6$ 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 A5.2.28.

Table A5.2.28 Uncertainty in New Zealand's 2023 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	$\pm 1,678.6$
Uncertainty in regenerating forest biomass carbon change	± 119.5
Uncertainty in soil carbon stocks	± 7.9
Uncertainty introduced into net emissions for LULUCF	± 17.8

Note: Land area includes land in transition in 2023. 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 in 2019 (the most recent data analysis) was estimated at 38.55 ± 10.23 tonnes C ha⁻¹. The associated uncertainty was ± 27.0 per cent. The average carbon stock change in post-1989 natural forest in 2019 was estimated at 2.48 ± 1.1 tonnes C ha⁻¹ yr⁻¹, with an associated uncertainty 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 A5.2.29.

Table A5.2.29 Uncertainty in New Zealand's 2023 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)	± 44.5
Uncertainty in soil carbon stocks	± 10.4
Uncertainty introduced into net emissions for LULUCF	± 1.3

Note: Land area includes land in transition in 2023. 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 ± 20.5 per cent at the 95 per cent confidence interval, while the uncertainty in carbon stock change (carbon gains) is ± 6.3 per cent (table A5.2.30). 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 et al., 2024) 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 A5.2.30.

Table A5.2.30 Uncertainty in New Zealand's 2023 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)	± 20.5
Uncertainty in planted forest biomass carbon stock change (gains)	± 6.3
Uncertainty in unstocked forest biomass carbon stocks	± 146.0
Uncertainty in riparian forest biomass carbon stocks	± 75.0
Uncertainty in soil carbon stocks	± 12.3
Uncertainty introduced into net emissions for LULUCF	± 48.8

Note: Land area includes land in transition in 2023. 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 ± 6.7 per cent (table A5.2.31). 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., 2024) 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 A5.2.31.

Table A5.2.31 Uncertainty in New Zealand's 2023 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)	± 6.7
Uncertainty in unstocked forest biomass carbon stocks	± 72.0
Uncertainty in riparian forest biomass carbon stocks	± 75.0
Uncertainty in soil carbon stocks	± 10.4
Uncertainty introduced into net emissions for LULUCF	± 23.6

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 A5.2.32).

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 A5.2.32). 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 per cent (based on table 5.6, IPCC, 2006b).

As shown in table A5.2.32, 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 A5.2.32 Uncertainty in New Zealand's 2023 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	±2.0	±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 A5.2.33).

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 A5.2.33). 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 grassland. The uncertainty associated with the IPCC default values is ±90.0 per cent (table 6.3, IPCC, 2006b).

Table A5.2.33 Uncertainty in New Zealand's 2023 carbon estimates for the *Grassland* category (including land in transition)

Land use	Uncertainty at a 95% confidence interval		
	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	±0.7	±5.6	±1.3

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 A5.2.34).

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., 2022) 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 A5.2.34 Uncertainty in New Zealand's 2023 carbon estimates for the *Wetlands* category (including land in transition)

Variable Land use	Uncertainty at a 95% confidence interval	
	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: 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; NA = not applicable.

Methods used to calculate uncertainty in *Settlements*

The uncertainty in mapping *Settlements* is ± 22.0 per cent (table A5.2.35).

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*.

Mineral soil organic carbon stocks have an estimated uncertainty of ± 95.0 per cent, with a soil carbon stock change from all conversions to and from settlements having an uncertainty of ± 100.0 per cent (apart from *Other land*, which applies a higher uncertainty, section A5.2.4, 'Mineral soils').

Table A5.2.35 Uncertainty in New Zealand's 2023 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: 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; NA = not applicable.

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*.

Mineral SOC stocks have an uncertainty of ±70.7 per cent, as calculated from the Tier 2 method estimates of SOC (table A5.2.36). 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 A5.2.36 Uncertainty in New Zealand's 2023 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: 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; NA = not applicable.

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 A5.2.37. Uncertainty in New Zealand's 2023 carbon estimates from emissions associated with *Harvested wood products* is provided in table A5.2.38.

Table A5.2.37 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 A5.2.38 Uncertainty in New Zealand's 2023 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	±19.6

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

Methods used to calculate uncertainty for nitrous oxide emissions from soils

Uncertainties for direct N₂O emission factors associated with drainage, as well as indirect N₂O emissions from leaching and runoff, are sourced from chapter 11 of the IPCC 2006 Guidelines (IPCC, 2006b). Table 11.1 and table 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 equation 3.3 and equation 3.4 in chapter 3 of the IPCC General Guidance and Reporting (IPCC, 2006c). For N₂O emissions associated with nitrogen mineralisation, an uncertainty of ±80.0 per cent is applied. Uncertainty associated with the variable used to calculate N₂O emissions from land-use change is summarised in table A5.2.39.

Table A5.2.39 Uncertainty in New Zealand's 2023 estimates from nitrous oxide (N₂O) emissions associated with land-use change

Source	Uncertainty at a 95% confidence interval (%)
Direct N₂O emissions from nitrogen mineralisation	
Activity data	±8.0
Soil carbon	±24.0
C:N ratio	±15.0
N ₂ O emission factor	±80.0
Direct N₂O emissions from drainage	
Activity data	±33.0
N ₂ O emission factor	±80.0
Indirect N₂O emissions from leaching and runoff	
Activity data	±8.0
N ₂ O 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 A5.2.40.

Table A5.2.40 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	-1,360.4	-1,438.3	0.0	250.4	250.4	0.032	1.3	5.9	3.2	0.0	0.1
Pre-1990 planted forest	CO ₂	-22,333.6	-14,185.3	0.0	69.4	69.4	0.238	17.7	58.3	12.3	0.0	1.5
Post-1989 planted forest	CO ₂	164.1	-2,110.1	0.0	225.9	225.9	0.056	9.2	8.7	20.9	0.0	4.3
Post-1989 natural forest	CO ₂	3.7	-754.6	0.0	35.4	35.4	0.000	3.1	3.1	1.1	0.0	0.0
Cropland perennial	CO ₂	126.1	62.8	0.0	147.3	147.3	0.000	0.2	0.3	0.3	0.0	0.0
Cropland annual	CO ₂	345.4	659.7	0.0	61.1	61.1	0.000	1.5	2.7	0.9	0.0	0.0
Grassland low producing	CO ₂	164.5	1,792.7	0.0	63.0	63.0	0.003	6.8	7.4	4.3	0.0	0.2
Grassland high producing	CO ₂	466.6	663.4	0.0	22.1	22.1	0.000	1.1	2.7	0.3	0.0	0.0
Grassland with woody biomass	CO ₂	72.2	398.0	0.0	65.2	65.2	0.000	1.4	1.6	0.9	0.0	0.0
Wetlands – open water	CO ₂	-17.8	-5.5	0.0	241.8	241.8	0.000	0.0	0.0	0.1	0.0	0.0
Wetlands – vegetative non-forest	CO ₂	0.1	-5.1	0.0	39.7	39.7	0.000	0.0	0.0	0.0	0.0	0.0
Wetlands – vegetative non-forest – peat extraction	CO ₂	9.4	18.0	0.0	18.9	18.9	0.000	0.0	0.1	0.0	0.0	0.0
Settlements	CO ₂	78.5	119.3	0.0	65.5	65.5	0.000	0.2	0.5	0.1	0.0	0.0
Other land	CO ₂	14.7	82.4	0.0	29.5	29.5	0.000	0.3	0.3	0.1	0.0	0.0
Harvested wood products	CO ₂	-2,437.8	-5,808.3	0.0	68.2	68.2	0.039	15.5	23.9	10.6	0.0	1.1
Direct N ₂ O emissions from N mineralisation/immobilisation	N ₂ O	165.1	117.7	8.0	85.1	85.5	0.000	0.1	0.5	0.1	0.0	0.0
Direct N ₂ O emissions from drainage and rewetting	N ₂ O	67.0	98.7	33.0	80.0	86.5	0.000	0.2	0.4	0.1	0.1	0.0
Indirect N ₂ O emissions from leaching and runoff	N ₂ O	37.2	26.5	8.0	126.6	126.8	0.000	0.0	0.1	0.0	0.0	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 (%)
N ₂ O emissions from biomass burning	N ₂ O	23.4	25.2	30.0	41.7	51.4	0.000	0.0	0.1	0.0	0.0	0.0
CH ₄ emissions from biomass burning	CH ₄	77.6	45.8	30.0	41.7	51.4	0.000	0.1	0.2	0.0	0.0	0.0
Total		-24,334.1	-20,197.1		Total uncertainty (%)		60.7			Total uncertainty in trend (%)		27.0

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 United Nations Framework Convention on Climate Change (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.

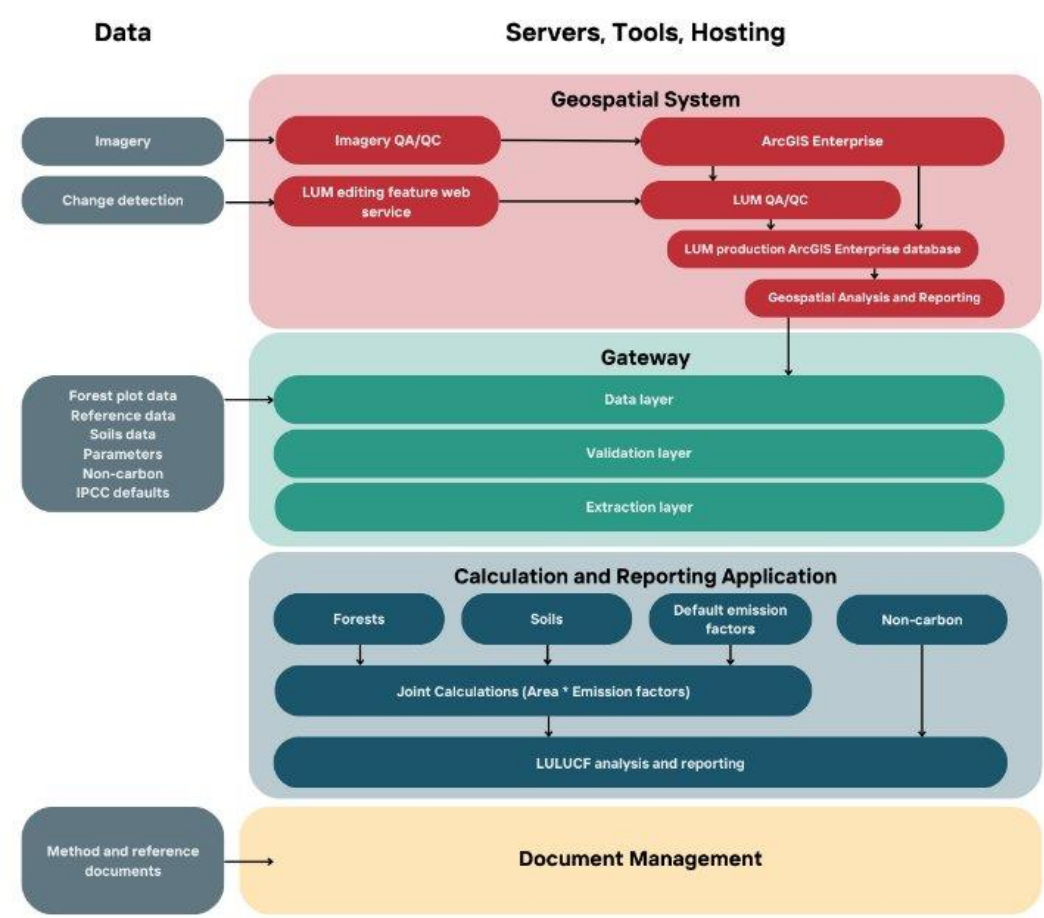
The main objectives of these systems are to:

- 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 Convention 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

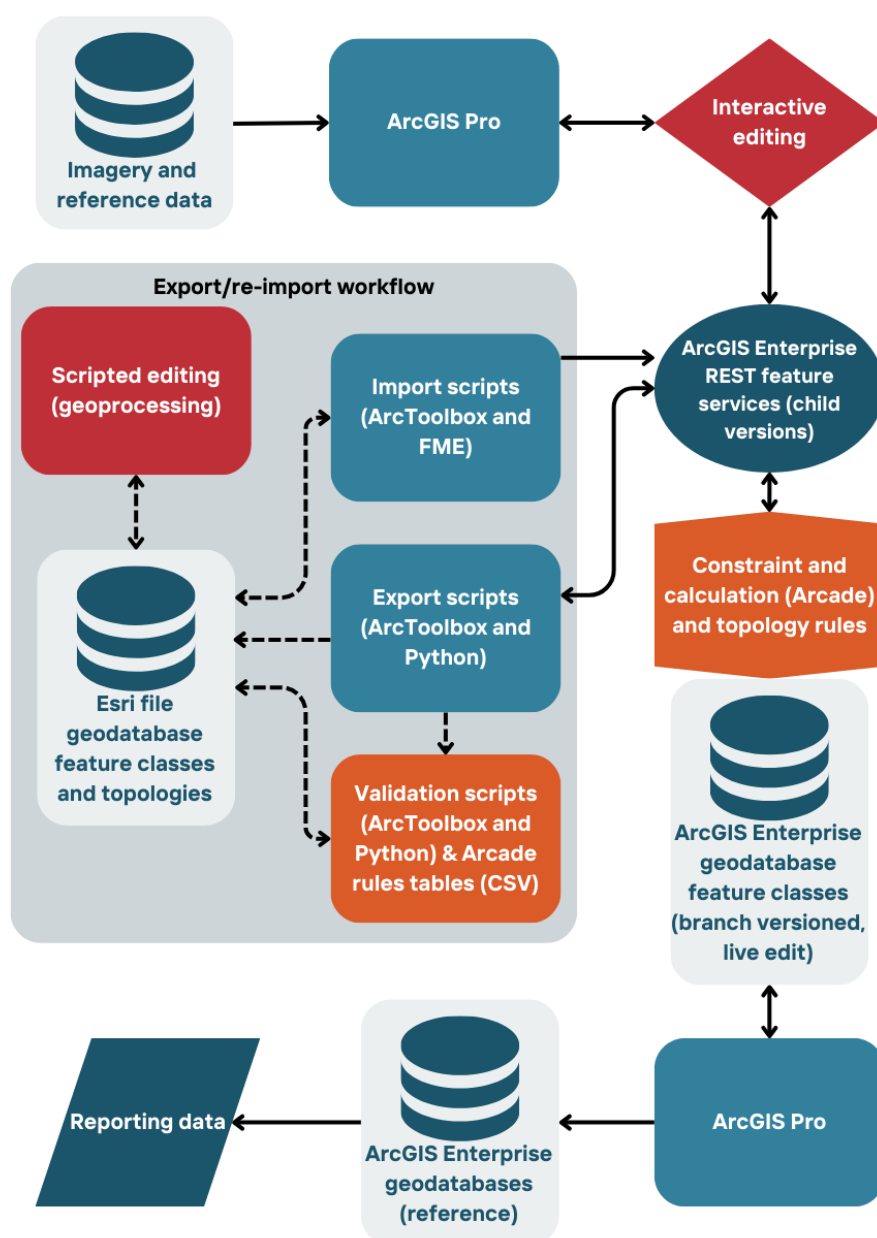


Note: IPCC = Intergovernmental Panel on Climate Change; LULUCF = Land Use, Land-Use Change and Forestry; LUM = land use map; QA/QC = quality assurance/quality control. Joint calculations are described below.

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 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 land use map is designed to represent land use and confirmed land-use change at each of the mapping dates of 1989, 2007, 2012, 2016 and 2020. 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 land use map.

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 access, 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.

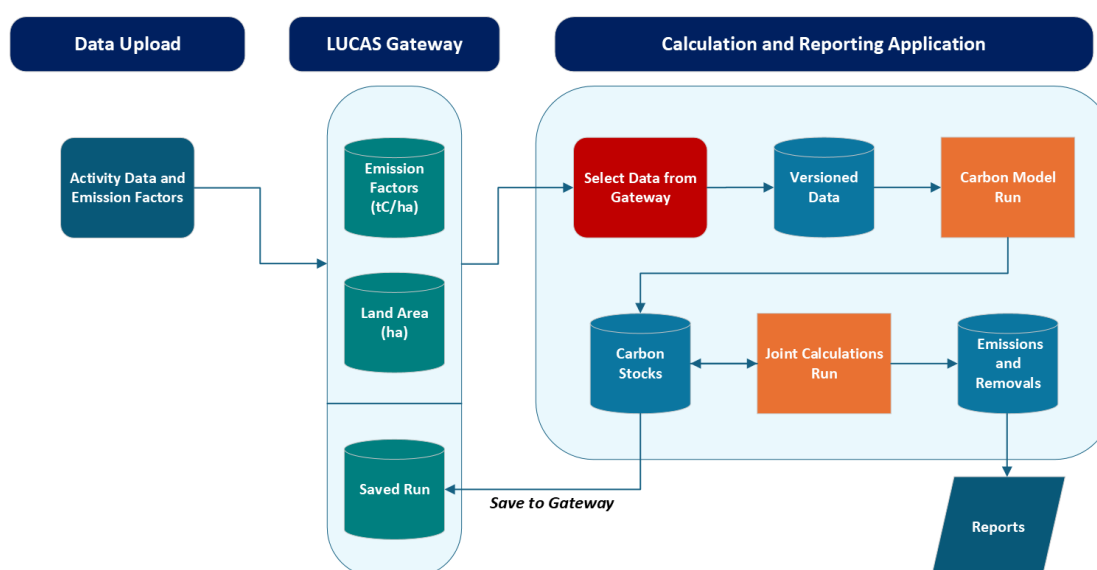
Production spatial data sets are stored in Esri ArcGIS Enterprise geodatabases. Some databases are used for reference and others for supporting web services.

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

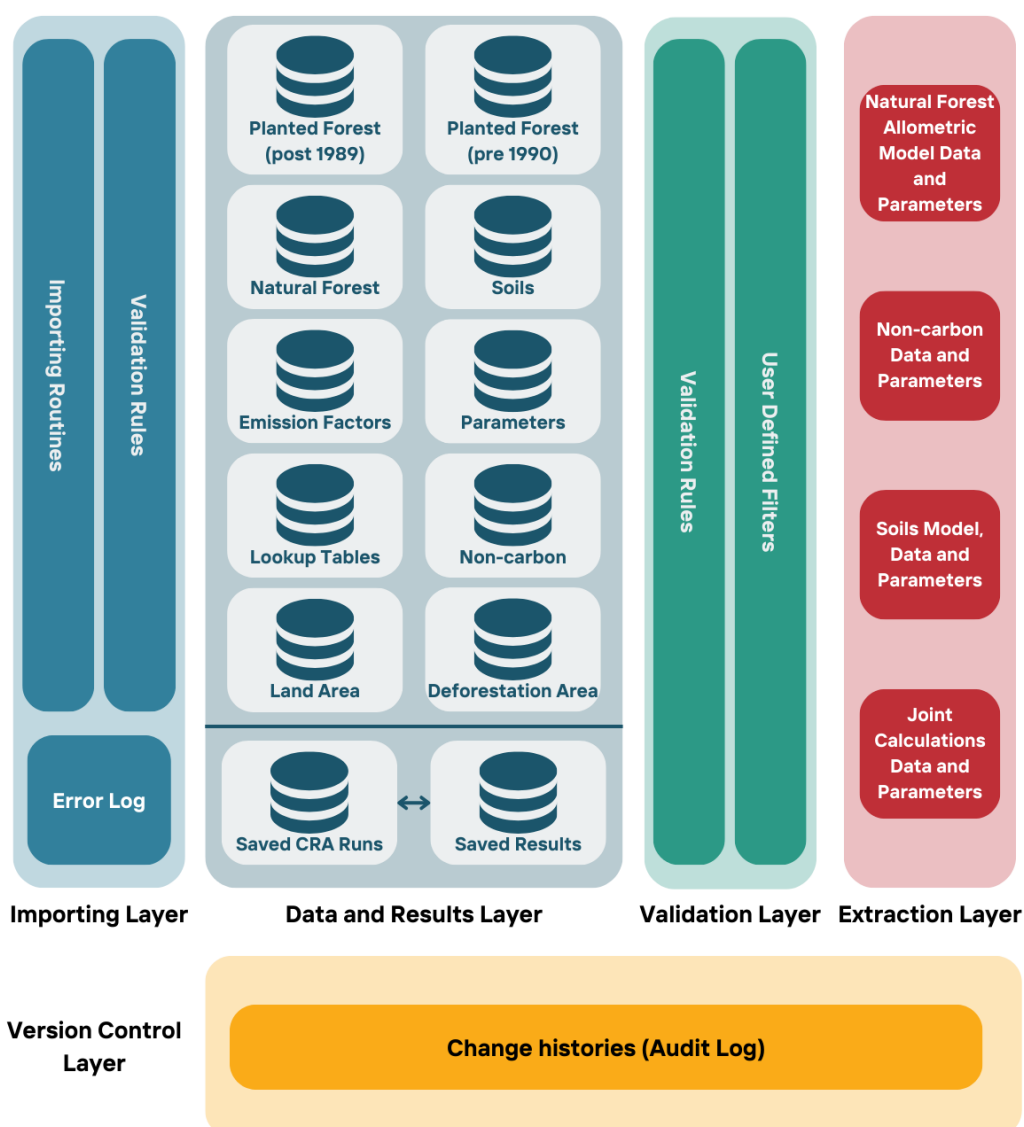
The LUCAS Gateway enables the storage of activity data such as field plot data, land use area, biomass burning and other data needed by the CRA, such as IPCC defaults.

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.

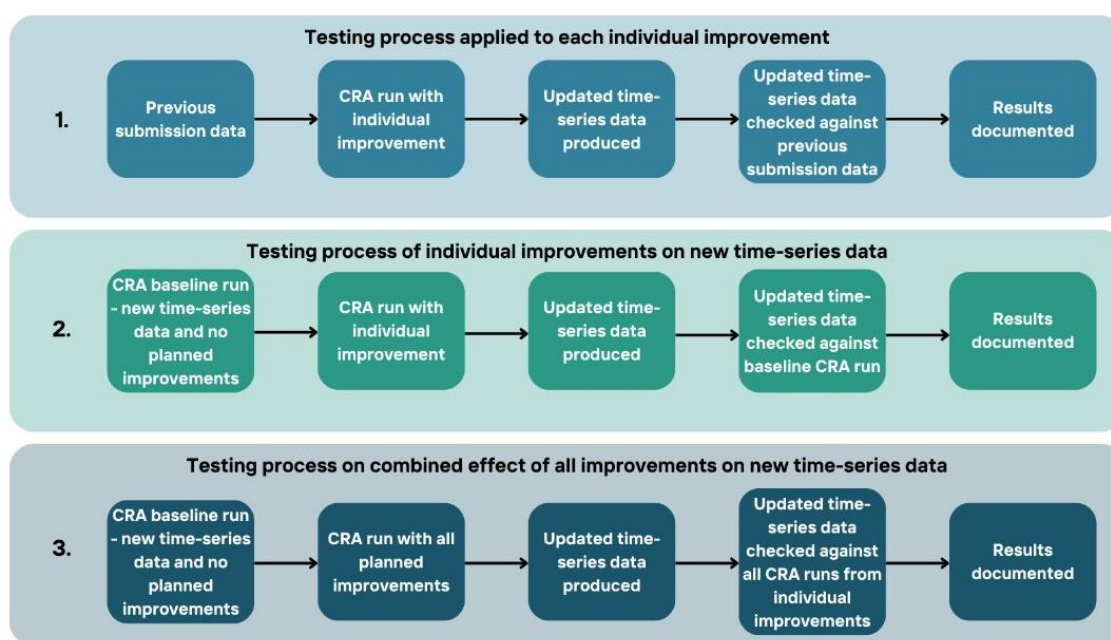
The CRA is maintained and supported by Interpine Innovation, a New Zealand-based company that specialises in forestry inventories and related information technology development. Interpine Innovation also provides support services, such as database and application backups, day-to-day issue resolution 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 managing improvements to the LULUCF sector of the Inventory. This was implemented to help manage the large number of improvements to the LULUCF sector that were introduced 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 to the LULUCF sector



Note: CRA = Calculation and Reporting Application.

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 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.

Table A5.3.1 Net-to-gross calorific value conversion factors

Fuel type	Factor
Gaseous	0.90
Liquid	0.95
Solid	0.95
Wood	0.80

Emission factors for gas, coal, biomass and liquid fuels used by New Zealand are shown in tables A5.3.2 to A5.3.5. 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 A5.3.2 Gross carbon dioxide emission factors used for New Zealand's energy sector for 2023

	Emission factor (t CO ₂ /TJ)	Source
Gas		
Weighted average	54.06	1
Liquid fuels		
Crude oil	69.67	2
Regular petrol	66.02	1
Petrol – premium	66.22	1
Diesel (10 parts (sulphur) per million)	69.20	1
Jet kerosene	67.93	1
Aviation gasoline	65.89	1
LPG	59.27	3
Heavy fuel oil	74.54	1
Light fuel oil	73.02	1
Bitumen (asphalt)	76.79	1
Biomass		
Biogas	49.17	2
Wood (industrial)	89.47	2
Bioethanol	64.20	1
Biodiesel	67.26	3
Wood (residential)	85.80	3
Coal		
All sectors excl. electricity (sub-bituminous)	96.09	1
All sectors (bituminous)	87.33	1
All sectors (lignite)	77.80	1

1. Derived by the Ministry of Business, Innovation and Employment.
2. IPCC Guidelines (2006a).
3. *New Zealand Energy Information Handbook* (Eng et al., 2008).

Table A5.3.3 Consumption-weighted average emission factors used for New Zealand's sub-bituminous coal-fired electricity generation for 1990 to 2023

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

Year	Emission factor (t CO ₂ /TJ)
2006	91.91
2007	92.43
2008	92.31
2009	92.39
2010–2017	92.20
2018	92.18
2019	92.64
2020	92.82
2021	92.95
2022	92.89
2023	92.80

Table A5.3.4 Methane emission factors used for New Zealand’s energy sector for 1990 to 2023

	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)
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 A5.3.5 Nitrous oxide emission factors used for New Zealand's energy sector for 1990 to 2023

	Emission factor (t N ₂ O/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

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 2023 statistical difference for liquid fuels in the balance table of the publication *Energy in New Zealand* was 2.5 per cent (MBIE, 2024). This is used as the activity data uncertainty for liquid fuels in 2023.

Emission factors and uncertainties

The CO₂ emission factors are described in table A5.3.2. 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 A5.3.6 gives a complete time series of carbon content of liquid fuels. This information was supplied by Refining NZ (until 2021) and derived from imported fuel data (from 2022) 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 CO₂ emission factors for liquid fuels at ± 0.5 per cent. The uncertainty for methane (CH₄) and N₂O emission factors is ± 50.0 per cent because almost all emission factors are IPCC defaults.

Table A5.3.7 provides emission factors for European gasoline and diesel vehicles from the COPERT IV model that are used to estimate non-CO₂ emissions from road transport.

Table A5.3.6 Carbon content (per cent mass) for liquid fuels for 1990 to 2023

	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
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
2023	85.13	84.98	86.49	85.91	86.74	86.96	86.53

**Table A5.3.7 Emission factors for European gasoline and diesel vehicles – COPERT IV model
(European Environment Agency, 2007)**

Vehicle type and emission standard	N ₂ O 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
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

Vehicle type and emission standard	N ₂ O emission factors (mg/km)				CH ₄ emission factors (mg/km)			
	Urban		Rural	Highway	Urban		Rural	Highway
	Cold	Hot			Cold	Hot		
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	175.0	175.0	80.0	70.0
Euro I	17.0		17.0	14.0	175.0	175.0	80.0	70.0
Euro II	17.0		17.0	14.0	112.0	112.0	69.6	65.1
Euro III	8.0		8.0	6.0	98.0	98.0	74.4	63.7
Euro IV	17.4		17.4	21.4	5.3	5.3	5.6	4.2
Euro V	45.6		45.6	61.6	5.3	5.3	5.6	4.2
Euro VI	56.5		56.5	59.5	5.3	5.3	5.6	4.2
	GVW>34t				GVW>34t			
pre-Euro	30.0		30.0	30.0	175.0	175.0	80.0	70.0
Euro I	18.0		18.0	15.0	175.0	175.0	80.0	70.0
Euro II	18.0		18.0	15.0	112.0	112.0	69.6	65.1
Euro III	9.0		9.0	7.0	98.0	98.0	74.4	63.7
Euro IV	19.0		19.0	23.4	5.3	5.3	5.6	4.2
Euro V	49.0		49.0	66.6	5.3	5.3	5.6	4.2
Euro VI	61.0		61.0	64.0	5.3	5.3	5.6	4.2
Urban bus or coach	All types				All types			
pre-Euro	30.0		30.0	30.0	175.0	175.0	80.0	70.0
Euro I	12.0		12.0	9.0	175.0	175.0	80.0	70.0
Euro II	12.0		12.0	9.0	113.8	113.8	52.0	45.5
Euro III	6.0		6.0	5.0	103.3	103.3	47.2	41.3
Euro IV	12.8		12.8	13.8	5.3	5.3	2.4	2.1
Euro V	33.2		33.2	40.2	5.3	5.3	2.4	2.1
Euro VI	41.5		41.5	39.0	5.3	5.3	2.4	2.1

Vehicle type and emission standard	N ₂ O emission factors (mg/km)					CH ₄ emission factors (mg/km)			
	Urban		Rural	Highway	Urban		Rural	Highway	
	Cold	Hot			Cold	Hot			
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

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 2023 statistical difference for solid fuels in the balance table of the publication *Energy in New Zealand* was 15.2 per cent (MBIE, 2024). This is used as the activity data uncertainty for solid fuels in 2023.

Emission factors and uncertainties

The estimated uncertainty in CO₂ 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 CH₄ and N₂O emission factors is ± 50.0 per cent because almost all emission factors are IPCC defaults.

A5.3.3 Emissions from gaseous fuels

Activity data

Through the various surveys and information it collects, MBIE has full coverage of the natural gas sector. This means that there is no sampling error in natural gas statistics and the only possible sources of error include those such as respondent error and processing error. The 2023 statistical difference for gaseous fuels in the balance table of the publication *Energy in New Zealand* was 7.5 per cent (MBIE, 2024). This is used as the activity data uncertainty for gaseous fuels in 2023.

Emission factors

The estimated uncertainty in CO₂ 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 2023. The uncertainty for CH₄ and N₂O emission factors is ± 50.0 per cent because almost all emission factors are IPCC defaults.

A5.4 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, 2024), 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 A5.4.1 gives a time series of energy use versus non-energy use of natural gas.

Table A5.4.1 Split of energy use and non-energy use of natural gas in petajoules

	Energy use	Non-energy use
1990	129.7	14.3
1991	144.2	20.9
1992	152.6	18.2
1993	148.0	20.2
1994	137.5	25.1
1995	126.8	36.5
1996	146.6	47.7
1997	169.8	48.9
1998	145.6	46.6
1999	165.5	54.2
2000	171.3	61.8
2001	190.2	55.3
2002	176.5	57.7
2003	149.6	26.1
2004	128.4	32.1
2005	134.8	13.0
2006	134.5	15.0
2007	149.8	15.4
2008	135.5	18.4
2009	132.5	25.7
2010	147.1	25.5
2011	133.5	24.6
2012	145.6	32.2
2013	148.2	40.6
2014	149.4	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	118.7	38.4
2022	111.1	31.3
2023	115.2	35.8

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 Agriculture 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 United Nations Climate Change [website](#) and the New Zealand Ministry for the Environment's [website](#).

Annex 7: Tokelau

A7.1 Emissions estimate data and supporting information by category for Tokelau¹⁰

Tokelau Table 1.A.1.a. Public electricity: 1. Energy > 1.A. Fuel combustion activities (sectoral approach) > 1.A.1. Energy industries > 1.A.1.a. Public electricity and heat production (Part 1 of 3)

Description	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 ₂ O		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 ₂ O		D	D	D	D	D	D	D	D	D	D	D

¹⁰ 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. Due to the automated method to populate this annex, three artefacts are introduced. First, values are presented to fewer decimal places to be practical for presentation. Second, where the last decimal place is a zero they are omitted. Third, some values ending in 5 are rounded down instead of up due to alternate rounding rules. Acronyms are as follows: C = carbon; CH₄ = methane; CO = carbon monoxide; CO₂ = carbon dioxide; D = default emission factor; DC = degradable carbon; dm = dry matter; F-gases = fluorinated gases; GCV = gross calorific value; HFCs = hydrofluorocarbons; h/day = hours per day; IE = included elsewhere; kg = kilograms; kt = kilotonnes; m³ = cubic metres; MCF = methane correction factor; MJ = megajoule; N = nitrogen; N₂O = nitrous oxide; NA = not applicable; NE = not estimated; NF₃ = nitrogen trifluoride; NMVOC = non-methane volatile organic compound; NO = not occurring; NO_x = nitrogen oxides; PFCs = perfluorocarbons; SF₆ = sulphur hexafluoride; SO_x = sulfur oxides; SWDS = solid waste disposable sites; t = tonnes; T1 = Tier 1 method; T1a = Tier 1a method; TJ = terajoule; VS = volatile solids; WWT = wastewater treatment.

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Emissions	kt CO ₂ equivalent	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231
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
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 ₂ O	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 ₂ O												
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. Public electricity: 1. Energy > 1.A. Fuel combustion activities (sectoral approach) > 1.A.1. Energy industries > 1.A.1.a. Public electricity and heat production (Part 2 of 3)

Description	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	GCV
Liquid fuels	GCV	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 ₂ O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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 ₂ O		D	D	D	D	D	D	D	D	D	D	D
Emissions	kt CO ₂ equivalent	0.231	0.231	0.231	0.692	1.154	1.154	1.154	1.154	1.154	1.154	1.154
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 ₂ O	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 ₂ O												
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. Public electricity: 1. Energy > 1.A. Fuel combustion activities (sectoral approach) > 1.A.1. Energy industries > 1.A.1.a. Public electricity and heat production (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
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	10.984
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	10.984
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Liquid fuels		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Method													
CO ₂		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH ₄		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N ₂ O		T1	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	D
CH ₄		D	D	D	D	D	D	D	D	D	D	D	D
N ₂ O		D	D	D	D	D	D	D	D	D	D	D	D
Emissions	kt CO ₂ equivalent	0.916	0.202	0.202	0.202	0.215	0.228	0.242	0.255	0.226	0.524	1.339	0.776
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	0.773
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	0.773
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	0.0000313
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	0.0000313
N ₂ O	kt	0.0000074	0.0000016	0.0000016	0.0000016	0.0000017	0.0000018	0.000002	0.0000021	0.0000018	0.0000042	0.0000108	0.0000063
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	0.0000063
Amount captured													
CO ₂	kt	NO	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	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	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	2.85
N ₂ O													
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	0.57

Tokelau Table 1.A.3.b.i. Gasoline: 1. Energy > 1.A. Fuel combustion activities (sectoral approach) > 1.A.3. Transport > 1.A.3.b. Road transportation > 1.A.3.b.i. Cars > Gasoline (Part 1 of 3)

Description	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 ₂ O		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 ₂ O		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 ₂ O	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Implied emission factor												
CO ₂	t/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CH ₄	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N ₂ O	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

Note: This category is included under 1.A.3.d. For explanation please refer to chapter 8, section 8.5.1.

Tokelau Table 1.A.3.b.i. Gasoline: 1. Energy > 1.A. Fuel combustion activities (sectoral approach) > 1.A.3. Transport > 1.A.3.b. Road transportation > 1.A.3.b.i. Cars > Gasoline (Part 2 of 3)

Description	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 ₂ O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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 ₂ O		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 ₂ O	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Implied emission factor												
CO ₂	t/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CH ₄	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N ₂ O	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

Tokelau Table 1.A.3.b.i. Gasoline: 1. Energy > 1.A. Fuel combustion activities (sectoral approach) > 1.A.3. Transport > 1.A.3.b. Road transportation > 1.A.3.b.i. Cars > Gasoline (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Fuel consumption	TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Calorific value		GCV	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	T1
CH ₄		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N ₂ O		T1	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	D
CH ₄		D	D	D	D	D	D	D	D	D	D	D	D
N ₂ O		D	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	IE
CH ₄	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N ₂ O	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Implied emission factor													
CO ₂	t/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CH ₄	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N ₂ O	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

Tokelau Table 1.A.3.b.i Diesel Oil: 1. Energy > 1.A. Fuel combustion activities (sectoral approach) > 1.A.3. Transport > 1.A.3.b. Road transportation > 1.A.3.b.i. Cars > Diesel oil (Part 1 of 3)

Description	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 _{4s}		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N ₂ O		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 ₂ O		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 ₂ O	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Implied emission factor												
CO ₂	t/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CH ₄	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N ₂ O	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

Tokelau Table 1.A.3.b.i Diesel Oil: 1. Energy > 1.A. Fuel combustion activities (sectoral approach) > 1.A.3. Transport > 1.A.3.b. Road transportation > 1.A.3.b.i. Cars > Diesel oil (Part 2 of 3)

Description	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 ₂ O		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 ₂ O		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 ₂ O	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Implied emission factor												
CO ₂	t/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CH ₄	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N ₂ O	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

Tokelau Table 1.A.3.b.i Diesel Oil: 1. Energy > 1.A. Fuel combustion activities (sectoral approach) > 1.A.3. Transport > 1.A.3.b. Road transportation > 1.A.3.b.i. Cars > Diesel oil (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Fuel consumption	TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Calorific value		IE	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	T1
CH ₄		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N ₂ O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Emission factor information													
CO ₂		D	D	D	D	D	D	D	D	D	D	D	D
CH ₄		D	D	D	D	D	D	D	D	D	D	D	D
N ₂ O		D	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	IE
CH ₄	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N ₂ O	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Implied emission factor													
CO ₂	t/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CH ₄	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N ₂ O	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

Tokelau Table 1.A.3.d. Gas-Diesel oil: 1. Energy > 1.A. Fuel combustion activities (sectoral approach) > 1.A.3. Transport > 1.A.3.d. Domestic navigation > Gas/Diesel oil (Part 1 of 3)

Description	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	GCV
Method												
CO ₂	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH ₄	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N ₂ O	T1	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	D
CH ₄	D	D	D	D	D	D	D	D	D	D	D	D
N ₂ O	D	D	D	D	D	D	D	D	D	D	D	D
Emissions		0.907	0.923	0.939	0.955	0.971	0.987	1.003	1.019	1.035	1.051	1.067
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 ₂ O	kt	0.0000242	0.0000247	0.0000251	0.0000255	0.000026	0.0000264	0.0000268	0.0000272	0.0000277	0.0000281	0.0000285

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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 ₂ O	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.A. Fuel combustion activities (sectoral approach) > 1.A.3. Transport > 1.A.3.d. Domestic navigation > Gas/Diesel oil (Part 2 of 3)

Description	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	GCV
Method												
CO ₂	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH ₄	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N ₂ O	T1	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	D
CH ₄	D	D	D	D	D	D	D	D	D	D	D	D
N ₂ O	D	D	D	D	D	D	D	D	D	D	D	D
Emissions		1.083	1.099	1.115	1.131	1.147	1.164	1.18	1.196	1.212	1.228	1.244
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 ₂ O	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 ₂ O	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.A. Fuel combustion activities (sectoral approach) > 1.A.3. Transport > 1.A.3.d. Domestic navigation > Gas/Diesel oil (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
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	20.186
Calorific value		GCV	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	T1
CH ₄		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N ₂ O		T1	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	D
CH ₄		D	D	D	D	D	D	D	D	D	D	D	D
N ₂ O		D	D	D	D	D	D	D	D	D	D	D	D
Emissions		1.26	1.276	1.292	1.282	1.342	1.413	1.498	2.198	2.074	1.384	1.319	1.435
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	1.421
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	0.0001342
N ₂ O	kt	0.0000337	0.0000341	0.0000345	0.0000343	0.0000359	0.0000378	0.00004	0.0000587	0.0000554	0.000037	0.0000353	0.0000384
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	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	6.65
N ₂ O	kg/TJ	1.9	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. Residential: 1. Energy > 1.A. Fuel combustion activities (sectoral approach) > 1.A.4. Other sectors > 1.A.4.b. Residential (Part 1 of 3)

Description	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

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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 ₂ O		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 ₂ O		D	D	D	D	D	D	D	D	D	D	D
Emissions	kt CO ₂ equivalent	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
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 ₂ O	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 _x	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	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
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

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CH ₄												
Liquid fuels	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
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 ₂ O												
Liquid fuels	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
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. Residential: 1. Energy > 1.A. Fuel combustion activities (sectoral approach) > 1.A.4. Other sectors > 1.A.4.b. Residential (Part 2 of 3)

Description	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	GCV
Liquid fuels	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Gaseous fuels	GCV	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	T1
CH ₄	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N ₂ O	T1	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	D
CH ₄	D	D	D	D	D	D	D	D	D	D	D	D
N ₂ O	D	D	D	D	D	D	D	D	D	D	D	D
Emissions	kt CO ₂ equivalent	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
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

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
N ₂ O	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
NM VOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
SO _x	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	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
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	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
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 ₂ O												
Liquid fuels	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
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. Residential: 1. Energy > 1.A. Fuel combustion activities (sectoral approach) > 1.A.4. Other sectors > 1.A.4.b. Residential (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
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	1.041
Liquid fuels	TJ	IE	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	1.041
Calorific value		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Liquid fuels		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV
Gaseous fuels		GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV	GCV

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Method													
CO ₂		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH ₄		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N ₂ O		T1	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	D
CH ₄		D	D	D	D	D	D	D	D	D	D	D	D
N ₂ O		D	D	D	D	D	D	D	D	D	D	D	D
Emissions	kt CO ₂ equivalent	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.073	0.103	0.097	0.1	0.061
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	0.059
Liquid fuels	kt	IE	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	0.059
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	0.0000581
Liquid fuels	kt	IE	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	0.0000581
N ₂ O	kt	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000002	0.0000003	0.0000003	0.0000003	0.0000002
Liquid fuels	kt	IE	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	0.0000002
NO _x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
SO _x	kt	NE	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	NO
Liquid fuels	kt	NO	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	NO
Implied emission factor													
CO ₂													
Liquid fuels	t/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
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	56.79

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
CH ₄													
Liquid fuels	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
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	55.8
N ₂ O													
Liquid fuels	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
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	0.18

Tokelau Table 1.A.4.c.iii Gas/Diesel Oil: 1. Energy > 1.A. Fuel combustion activities (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)

Description	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 ₂ O		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 ₂ O		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 ₂ O	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Implied emission factor												
CO ₂	t/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CH ₄	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N ₂ O	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

Tokelau Table 1.A.4.c.iii Gas/Diesel Oil: 1. Energy > 1.A. Fuel combustion activities (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)

Description	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 ₂ O		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 ₂ O		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 ₂ O	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Implied emission factor												
CO ₂	t/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CH ₄	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N ₂ O	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

Tokelau Table 1.A.4.c.iii Gas/Diesel Oil: 1. Energy > 1.A. Fuel combustion activities (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)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Fuel consumption	TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Calorific value		GCV	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	T1
CH ₄		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N ₂ O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Emission factor information													
CO ₂		D	D	D	D	D	D	D	D	D	D	D	D
CH ₄		D	D	D	D	D	D	D	D	D	D	D	D
N ₂ O		D	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	IE
CH ₄	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N ₂ O	kt	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Implied emission factor													
CO ₂	t/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CH ₄	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
N ₂ O	kg/TJ	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

Tokelau Table 1.A(b). Gasoline: 1. Energy > 1.A(b). CO₂ from fuel combustion activities (reference approach) > Liquid fuels > Secondary fuels > Gasoline (Part 1 of 3)

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Unit		TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
Imports	unit	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802
Exports	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	unit	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802
Conversion factor	TJ/unit	1	1	1	1	1	1	1	1	1	1	1
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

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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												
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.A(b). Gasoline: 1. Energy > 1.A(b). CO₂ from fuel combustion activities (reference approach) > Liquid fuels > Secondary fuels > Gasoline (Part 2 of 3)

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Unit		TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
Imports	unit	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802
Exports	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	unit	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.802
Conversion factor	TJ/unit	1	1	1	1	1	1	1	1	1	1	1
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												
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.A(b). Gasoline: 1. Energy > 1.A(b). CO₂ from fuel combustion activities (reference approach) > Liquid fuels > Secondary fuels > Gasoline (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Unit		TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
Imports	unit	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.387	11.262	10.69	8.687	8.618
Exports	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	unit	9.802	9.802	9.802	9.802	9.802	9.802	9.802	9.387	11.262	10.69	8.687	8.618
Conversion factor	TJ/unit	1	1	1	1	1	1	1	1	1	1	1	1
Calorific value		GCV	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	8.618
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	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	0.155
Carbon stored													
C	kt	NO	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	0.155
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1	1	1
Emissions													
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	0.567

Tokelau Table 1.A(b). Gas-Diesel oil: 1. Energy > 1.A(b). CO₂ from fuel combustion activities (reference approach) > Liquid fuels > Secondary fuels > Gas/Diesel oil (Part 1 of 3)

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Unit		TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
Imports	unit	5.834	6.059	6.285	6.511	6.736	6.962	7.188	7.413	7.639	7.865	8.09
Exports	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Apparent consumption	unit	5.834	6.059	6.285	6.511	6.736	6.962	7.188	7.413	7.639	7.865	8.09
Conversion factor	TJ/unit	1	1	1	1	1	1	1	1	1	1	1
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												
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.A(b). Gas-Diesel oil: 1. Energy > 1.A(b). CO₂ from fuel combustion activities (reference approach) > Liquid fuels > Secondary fuels > Gas/Diesel oil (Part 2 of 3)

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Unit		TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
Imports	unit	8.316	8.542	8.767	15.53	22.292	22.518	22.743	22.969	23.195	23.42	23.646
Exports	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	unit	8.316	8.542	8.767	15.53	22.292	22.518	22.743	22.969	23.195	23.42	23.646
Conversion factor	TJ/unit	1	1	1	1	1	1	1	1	1	1	1
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

Description	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												
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.A(b). Gas-Diesel oil: 1. Energy > 1.A(b). CO₂ from fuel combustion activities (reference approach) > Liquid fuels > Secondary fuels > Gas/Diesel oil (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Unit	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
Imports	unit	20.502	10.618	10.844	10.701	11.743	12.927	14.308	24.984	20.916	16.095	28.527	22.034
Exports	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	unit	20.502	10.618	10.844	10.701	11.743	12.927	14.308	24.984	20.916	16.095	28.527	22.034
Conversion factor	TJ/unit	1	1	1	1	1	1	1	1	1	1	1	1
Calorific value	GCV	GCV	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	22.034
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	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	0.423
Carbon stored													
C	kt	NO	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	0.423
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1	1	1
Emissions													
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	1.55

Tokelau Table 1.A(b). Other kerosene: 1. Energy > 1.A(b). CO₂ from fuel combustion activities (reference approach) > Liquid fuels > Secondary fuels > Other kerosene (Part 1 of 3)

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Unit		TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
Imports	unit	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666
Exports	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	unit	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666
Conversion factor	TJ/unit	1	1	1	1	1	1	1	1	1	1	1
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												
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.A(b). Other kerosene: 1. Energy > 1.A(b). CO₂ from fuel combustion activities (reference approach) > Liquid fuels > Secondary fuels > Other kerosene (Part 2 of 3)

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Unit		TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
Imports	unit	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666
Exports	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Apparent consumption	unit	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666
Conversion factor	TJ/unit	1	1	1	1	1	1	1	1	1	1	1
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												
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.A(b). Other kerosene: 1. Energy > 1.A(b). CO₂ from fuel combustion activities (reference approach) > Liquid fuels > Secondary fuels > Other kerosene (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Unit		TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
Imports	unit	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.234	0.095	0.205	0.769	0.051
Exports	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	unit	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.234	0.095	0.205	0.769	0.051
Conversion factor	TJ/unit	1	1	1	1	1	1	1	1	1	1	1	1
Calorific value		GCV	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	0.051
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	18.62

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
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	0.0009541
Carbon stored													
C	kt	NO	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	0.004	0.002	0.004	0.014	0.0009541
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1	1	1
Emissions													
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	0.003

Tokelau Table 1.A(b). Liquefied petroleum: 1. Energy > 1.A(b). CO₂ from fuel combustion activities (reference approach) > Liquid fuels > Secondary fuels > Liquefied petroleum gases (LPG)
(Part 1 of 3)

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Unit		TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
Imports	unit	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491
Exports	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	unit	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491
Conversion factor	TJ/unit	1	1	1	1	1	1	1	1	1	1	1
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												
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.A(b). Liquefied petroleum: 1. Energy > 1.A(b). CO₂ from fuel combustion activities (reference approach) > Liquid fuels > Secondary fuels > Liquefied petroleum gases (LPG)
(Part 2 of 3)

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Unit		TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
Imports	unit	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491
Exports	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	unit	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491
Conversion factor	TJ/unit	1	1	1	1	1	1	1	1	1	1	1
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												
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.A(b). Liquefied petroleum: 1. Energy > 1.A(b). CO₂ from fuel combustion activities (reference approach) > Liquid fuels > Secondary fuels > Liquefied petroleum gases (LPG)
(Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Unit		TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
Imports	unit	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.017	1.667	1.459	0.943	0.989
Exports	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	unit	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.017	1.667	1.459	0.943	0.989

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Conversion factor	TJ/unit	1	1	1	1	1	1	1	1	1	1	1	1
Calorific value		GCV	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	0.989
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	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	0.015
Carbon stored													
C	kt	NO	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	0.015
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1	1	1
Emissions													
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	0.056

Tokelau Table 1.A(b). Lubricants: 1. Energy > 1.A(b). CO₂ from fuel combustion activities (reference approach) > Liquid fuels > Secondary fuels > Lubricants (Part 1 of 3)

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Unit		TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
Imports	unit	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
Exports	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	unit	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
Conversion factor	TJ/unit	1	1	1	1	1	1	1	1	1	1	1
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

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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												
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.A(b). Lubricants: 1. Energy > 1.A(b). CO₂ from fuel combustion activities (reference approach) > Liquid fuels > Secondary fuels > Lubricants (Part 2 of 3)

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Unit		TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
Imports	unit	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
Exports	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	unit	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
Conversion factor	TJ/unit	1	1	1	1	1	1	1	1	1	1	1
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												
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.A(b). Lubricants: 1. Energy > 1.A(b). CO₂ from fuel combustion activities (reference approach) > Liquid fuels > Secondary fuels > Lubricants (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Unit		TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
Imports	unit	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.152	0.203	0.101	0.303	0.518
Exports	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International bunkers	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Stock change	unit	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Apparent consumption	unit	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.152	0.203	0.101	0.303	0.518
Conversion factor	TJ/unit	1	1	1	1	1	1	1	1	1	1	1	1
Calorific value		GCV	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	0.518
Emission factor													
C	t/TJ	19	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	0.01
Carbon stored													
C	kt	NO	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	0.01
Fraction of carbon oxidized		1	1	1	1	1	1	1	1	1	1	1	1
Emissions													
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	0.038

Tokelau Table 2.F.1.b. 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.b. Domestic refrigeration > HFC-134a (Part 1 of 3)

Description	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
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: 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)

Description	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: 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)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Amount													
Filled into new manufactured products	t	NO	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	0.208
Remaining in products at decommissioning	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	0.043	0.04	0.037	0.034	0.031	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	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	0.031
From disposal	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Recovery	t	NO	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	NO
Product life factor	%	15	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	NO

Tokelau Table 2.F.1.f. Stationary air-con: 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)

Description	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												
Aggregate F-gases	t CO ₂ equivalent	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFCs	t CO ₂ equivalent	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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
Recovery												
Aggregate F-gases	t CO ₂ equivalent	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau Table 2.F.1.f. Stationary air-con: 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)

Description	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												
Aggregate F-gases	t CO ₂ equivalent	NO	NO	NO	NO	NO	NO	15.651	31.302	46.953	62.603	78.254
HFCs	t CO ₂ equivalent	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
Recovery												
Aggregate F-gases	t CO ₂ equivalent	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau Table 2.F.1.f. Stationary air-con: 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)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Method													
HFCs		T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a
PFCs		NA	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	NA
SF ₆		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NF ₃		NA	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	D
Emissions													
Aggregate F-gases	t CO ₂ equivalent	93.905	109.556	125.207	140.858	156.509	156.509	156.509	156.509	156.509	156.509	156.509	156.509
HFCs	t CO ₂ equivalent	93.905	109.556	125.207	140.858	156.509	156.509	156.509	156.509	156.509	156.509	156.509	156.509
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	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	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	0.003
Recovery													
Aggregate F-gases	t CO ₂ equivalent	NO	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 1 of 3)

Description	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

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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)

Description	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)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Amount													
Filled into new manufactured products	t	NO	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	0.203
Remaining in products at decommissioning	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Emissions	t	0.018	0.021	0.024	0.027	0.03	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	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	0.03
From disposal	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Recovery	t	NO	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	NO
Product life factor	%	15	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	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)

Description	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)

Description	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)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Amount													
Filled into new manufactured products	t	NO	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	0.278
Remaining in products at decommissioning	t	NO	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	0.042
From manufacturing	t	NO	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	0.042
From disposal	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Recovery	t	NO	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	NO
Product life factor	%	15	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	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)

Description	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)

Description	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)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Amount													
Filled into new manufactured products	t	NO	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	0.019
Remaining in products at decommissioning	t	NO	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	0.003
From manufacturing	t	NO	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	0.003
From disposal	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Recovery	t	NO	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	NO
Product life factor	%	15	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	NO

Tokelau Table 2.F.4.a. Metered dose inhaler: 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)

Description	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

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Emissions	kt CO ₂ equivalent	NO	NO	NO	NO	NO	0.000108	0.0006358	0.001	0.002	0.002	0.003
Aggregate F-gases	t CO ₂ equivalent	NO	NO	NO	NO	NO	0.108	0.636	1.04	1.538	2.218	2.594
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
Recovery												
Aggregate F-gases	t CO ₂ equivalent	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau Table 2.F.4.a. Metered dose inhaler: 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)

Description	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
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
Aggregate F-gases	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
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
Recovery												
Aggregate F-gases	t CO ₂ equivalent	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Tokelau Table 2.F.4.a. Metered dose inhaler: 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)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Method													
HFCs		T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a
PFCs		NA	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	NA
SF ₆		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NF ₃		NA	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	D
PFCs		NA	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	NA
SF ₆		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NF ₃		NA	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	0.014
Aggregate F-gases	t CO ₂ equivalent	17.512	17.663	17.669	17.945	17.86	17.414	16.865	16.374	15.085	13.77	14.059	14.059
HFCs	t CO ₂ equivalent	17.512	17.663	17.669	17.945	17.86	17.414	16.865	16.374	15.085	13.77	14.059	14.059
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	0.009
HFC-227ea	t	0.0007195	0.0007207	0.0007209	0.0007322	0.0007197	0.0006808	0.0006386	0.0006042	0.0005371	0.0004762	0.0005326	0.0005326
Recovery													
Aggregate F-gases	t CO ₂ equivalent	NO	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)

Description	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)

Description	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)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Amount													
Filled into new manufactured products	t	NO	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	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	0.009
From manufacturing	t	NO	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	0.009
Recovery	t	NO	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	NO
Product life factor	%	100	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)

Description	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)

Description	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)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Amount													
Filled into new manufactured products	t	NO	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	0.0004762	0.0005326	0.0005326
Emissions	t	0.0007195	0.0007207	0.0007209	0.0007322	0.0007197	0.0006808	0.0006386	0.0006042	0.0005371	0.0004762	0.0005326	0.0005326
From manufacturing	t	NO	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	0.0004762	0.0005326	0.0005326
Recovery	t	NO	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	NO
Product life factor	%	100	100	100	100	100	100	100	100	100	100	100	100

Tokelau Table 2.G.3.a. Medical applications: 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)

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Activity Data												
N ₂ O	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 ₂ O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information												
N ₂ O		D	D	D	D	D	D	D	D	D	D	D
Emissions												
N ₂ O	kt	0.000154	0.0001428	0.0001337	0.0001249	0.0001166	0.0001086	0.0001012	0.0000944	0.0000884	0.0000828	0.0000776
Recovery												
N ₂ O	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor												
N ₂ O	t/t	1	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. Medical applications: 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)

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Activity Data												
N ₂ O	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 ₂ O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information												
N ₂ O		D	D	D	D	D	D	D	D	D	D	D
Emissions												
N ₂ O	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 ₂ O	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor												
N ₂ O	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. Medical applications: 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)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Activity Data													
N ₂ O	kt	0.0000538	0.000054	0.0000536	0.0000564	0.0000506	0.0000597	0.0000838	0.0000596	0.000067	0.0000853	0.0000949	0.0000949
Method													
N ₂ O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
Emission factor information													
N ₂ O		D	D	D	D	D	D	D	D	D	D	D	D
Emissions													
N ₂ O	kt	0.00005	0.0000539	0.0000536	0.0000547	0.0000532	0.0000547	0.0000713	0.0000711	0.0000629	0.0000761	0.0000898	0.0000898
Recovery													
N ₂ O	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Implied emission factor													
N ₂ O	t/t	0.93	0.999	1.001	0.971	1.052	0.916	0.851	1.193	0.939	0.892	0.946	0.946

Tokelau Table 3.A.3.a. Pigs: 3. Agriculture > 3.A. Enteric fermentation > 3.A.3. Swine > 3.A.3.a. Other (please specify) > Pigs (Part 1 of 3)

Description	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

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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

Tokelau Table 3.A.3.a. Pigs: 3. Agriculture > 3.A. Enteric fermentation > 3.A.3. Swine > 3.A.3.a. Other (please specify) > Pigs (Part 2 of 3)

Description	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

Tokelau Table 3.A.3.a. Pigs: 3. Agriculture > 3.A. Enteric fermentation > 3.A.3. Swine > 3.A.3.a. Other (please specify) > Pigs (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Population	1000s	2.219	2.076	1.933	1.79	1.647	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	NA
Average CH ₄ conversion rate	%	NA	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	T1
Emission factor information													
CH ₄		D	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	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	1.5
Additional information													
Weight	kg	80	80	80	80	80	80	80	80	80	80	80	80
Feeding situation		Pen	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	NA
Work	h/day	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Pregnant	%	NA	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	NA

Tokelau Table 3.A.4.g. Poultry: 3. Agriculture > 3.A. Enteric fermentation > 3.A.4. Other livestock > 3.A.4.g. Poultry (Part 1 of 3)

Description	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

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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

Tokelau Table 3.A.4.g. Poultry: 3. Agriculture > 3.A. Enteric fermentation > 3.A.4. Other livestock > 3.A.4.g. Poultry (Part 2 of 3)

Description	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

Tokelau Table 3.A.4.g. Poultry: 3. Agriculture > 3.A. Enteric fermentation > 3.A.4. Other livestock > 3.A.4.g. Poultry (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Population	1000s	0.976	0.888	0.801	0.713	0.625	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	NA
Average CH ₄ conversion rate	%	NA	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	NA
Emission factor information													
CH ₄		NA	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	NE
Implied emission factor													
CH ₄	kg/head/year	NE	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	NA
Feeding situation		NA	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	NA
Work	h/day	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pregnant	%	NA	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	NA

Tokelau Table 3.B.3.a. Pigs: 3. Agriculture > 3.B. Manure management > 3.B(a). CH₄ emissions > 3.B.3. Swine > 3.B.3.a. Other (please specify) > Pigs (Part 1 of 3)

Description	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

Description	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.3.a. Pigs: 3. Agriculture > 3.B. Manure management > 3.B(a). CH₄ emissions > 3.B.3. Swine > 3.B.3.a. Other (please specify) > Pigs (Part 2 of 3)

Description	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.3.a. Pigs: 3. Agriculture > 3.B. Manure management > 3.B(a). CH₄ emissions > 3.B.3. Swine > 3.B.3.a. Other (please specify) > Pigs (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Population	1000s	2.219	2.076	1.933	1.79	1.647	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	100	100	100	100	100	100
Typical animal mass (average)	kg	80	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	NA
CH ₄ producing potential (average)	m ³ /kg VS	NA	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	T1
Emission factor information													
CH ₄		D	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	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	18.5

Tokelau Table 3.B.4.g. Poultry: 3. Agriculture > 3.B. Manure management > 3.B(a). CH₄ emissions > 3.B.4. Other livestock > 3.B.4.g. Poultry (Part 1 of 3)

Description	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

Description	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	0.0001032	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.4.g. Poultry: 3. Agriculture > 3.B. Manure management > 3.B(a). CH₄ emissions > 3.B.4. Other livestock > 3.B.4.g. Poultry (Part 2 of 3)

Description	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.4.g. Poultry: 3. Agriculture > 3.B. Manure management > 3.B(a). CH₄ emissions > 3.B.4. Other livestock > 3.B.4.g. Poultry (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Population	1000s	0.976	0.888	0.801	0.713	0.625	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	NO
Temperate	%	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Warm	%	100	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	NA
VS daily excretion (average)	kg dm/head/day	NA	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	NA
Method													
CH ₄		T1	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	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	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	0.03

Tokelau Table 5.A. Solid waste disposal: 5. Waste > 5.A. Solid waste disposal (Part 1 of 3)

Description	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
Emission factor information												
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
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
NM VOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

Tokelau Table 5.A. Solid waste disposal: 5. Waste > 5.A. Solid waste disposal (Part 2 of 3)

Description	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
Emission factor information												
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
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
NM VOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

Tokelau Table 5.A. Solid waste disposal: 5. Waste > 5.A. Solid waste disposal (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Method													
CH ₄		T1	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	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	0.347
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	0.012
NO _x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NM VOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

Tokelau Table 5.A.3. Uncategorized waste: 5. Waste > 5.A. Solid waste disposal > 5.A.3. Uncategorized waste disposal sites (Part 1 of 3)

Description	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
Method												
CH ₄		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1

Description	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	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
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
NM VOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Implied emission factor												
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. Uncategorized waste: 5. Waste > 5.A. Solid waste disposal > 5.A.3. Uncategorized waste disposal sites (Part 2 of 3)

Description	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
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	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
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
NM VOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Implied emission factor												
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. Uncategorized waste: 5. Waste > 5.A. Solid waste disposal > 5.A.3. Uncategorized waste disposal sites (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
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	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	0.6
Method													
CH ₄		T1	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	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	0.347
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	0.012
Amount of CH ₄ flared	kt	NO	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
NO _x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NM VOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Implied emission factor													
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	0.028

Tokelau Table 5.C.2. Open burning of waste: 5. Waste > 5.C. Incineration and open burning of waste > 5.C.2. Open burning of waste (Part 1 of 3)

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Amount of wastes open burned	kt wet weight	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 ₂ O		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 ₂ O		D	D	D	D	D	D	D	D	D	D	D

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Emissions	kt CO ₂ equivalent	0.157	0.154	0.154	0.153	0.153	0.152	0.151	0.15	0.149	0.148	0.147
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 ₂ O	kt	0.0000455	0.0000446	0.0000445	0.0000443	0.0000441	0.0000439	0.0000438	0.0000434	0.0000431	0.0000428	0.0000424
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
NM VOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
SO _x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
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 ₂ O	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. Open burning of waste: 5. Waste > 5.C. Incineration and open burning of waste > 5.C.2. Open burning of waste (Part 2 of 3)

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Amount of wastes open burned	kt wet weight	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 ₂ O		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 ₂ O		D	D	D	D	D	D	D	D	D	D	D
Emissions	kt CO ₂ equivalent	0.145	0.14	0.134	0.128	0.122	0.116	0.117	0.118	0.119	0.12	0.121
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 ₂ O	kt	0.0000421	0.0000404	0.0000386	0.0000369	0.0000352	0.0000334	0.0000337	0.0000341	0.0000344	0.0000347	0.000035
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

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
NM VOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
SO _x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
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 ₂ O	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. Open burning of waste: 5. Waste > 5.C. Incineration and open burning of waste > 5.C.2. Open burning of waste (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Amount of wastes open burned	kt wet weight	0.421	0.427	0.432	0.438	0.443	0.444	0.445	0.447	0.447	0.447	0.447	0.447
Method													
CO ₂		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH ₄		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N ₂ O		T1	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	D
CH ₄		D	D	D	D	D	D	D	D	D	D	D	D
N ₂ O		D	D	D	D	D	D	D	D	D	D	D	D
Emissions	kt CO ₂ equivalent	0.123	0.124	0.126	0.127	0.129	0.129	0.129	0.13	0.13	0.13	0.13	0.13
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	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	0.003
N ₂ O	kt	0.0000355	0.0000359	0.0000364	0.0000369	0.0000373	0.0000374	0.0000374	0.0000376	0.0000376	0.0000376	0.0000376	0.0000376
NO _x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NM VOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
SO _x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
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	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	6.5
N ₂ O	kg/t	0.084	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.b.i. Municipal solid: 5. Waste > 5.C. Incineration and open burning of waste > 5.C.2. Open burning of waste > 5.C.2.b. Non-biogenic > 5.C.2.b.i. Municipal solid waste (Part 1 of 3)

Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Amount of wastes open burned	kt wet weight	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 ₂ O		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 ₂ O		D	D	D	D	D	D	D	D	D	D	D
Emissions		0.157	0.154	0.154	0.153	0.153	0.152	0.151	0.15	0.149	0.148	0.147
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 ₂ O	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 ₂ O	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.b.i. Municipal solid: 5. Waste > 5.C. Incineration and open burning of waste > 5.C.2. Open burning of waste > 5.C.2.b. Non-biogenic > 5.C.2.b.i. Municipal solid waste (Part 2 of 3)

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Amount of wastes open burned	kt wet weight	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 ₂ O		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

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
CH ₄		D	D	D	D	D	D	D	D	D	D	D
N ₂ O		D	D	D	D	D	D	D	D	D	D	D
Emissions		0.145	0.14	0.134	0.128	0.122	0.116	0.117	0.118	0.119	0.12	0.121
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 ₂ O	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 ₂ O	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.b.i. Municipal solid: 5. Waste > 5.C. Incineration and open burning of waste > 5.C.2. Open burning of waste > 5.C.2.b. Non-biogenic > 5.C.2.b.i. Municipal solid waste (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Amount of wastes open burned	kt wet weight	0.421	0.427	0.432	0.438	0.443	0.444	0.445	0.447	0.447	0.447	0.447	0.447
Method													
CO ₂		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
CH ₄		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N ₂ O		T1	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	D
CH ₄		D	D	D	D	D	D	D	D	D	D	D	D
N ₂ O		D	D	D	D	D	D	D	D	D	D	D	D
Emissions		0.123	0.124	0.126	0.127	0.129	0.129	0.129	0.13	0.13	0.13	0.13	0.13
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	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	0.003
N ₂ O	kt	0.0000355	0.0000359	0.0000364	0.0000369	0.0000373	0.0000374	0.0000374	0.0000376	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	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	6.5
N ₂ O	kg/t	0.084	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. Wastewater treatment: 5. Waste > 5.D. Wastewater treatment and discharge (Part 1 of 3)

Description	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 ₂ O		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 ₂ O		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 ₂ O	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
NM VOC	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
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. Wastewater treatment: 5. Waste > 5.D. Wastewater treatment and discharge (Part 2 of 3)

Description	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 ₂ O		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 ₂ O		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 ₂ O	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
NM VOC	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. Wastewater treatment: 5. Waste > 5.D. Wastewater treatment and discharge (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Method													
CH ₄		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N ₂ O		T1	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	D
N ₂ O		D	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	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	0.011
N ₂ O	kt	0.0000051	0.0000039	0.0000026	0.0000013	NO	NO	NO	NO	NO	NO	NO	NO
NO _x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	kt	NE	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	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	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	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	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	1.25
Degree of utilization of modern, centralized WWT plants	%	0	0	0	0	0	0	0	0	0	0	0	0

Tokelau Table 5.D.1. Domestic wastewater: 5. Waste > 5.D. Wastewater treatment and discharge > 5.D.1. Domestic wastewater (Part 1 of 3)

Description	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 ₂ O		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1

Description	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
N ₂ O		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												
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 ₂ O												
Emissions	kt	0.0000593	0.0000562	0.0000537	0.0000511	0.0000486	0.0000461	0.0000436	0.0000379	0.0000323	0.0000268	0.0000214
Plants	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Effluent	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
NM VOC	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 ₂ O	kg N ₂ O-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. Domestic wastewater: 5. Waste > 5.D. Wastewater treatment and discharge > 5.D.1. Domestic wastewater (Part 2 of 3)

Description	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 ₂ O		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 ₂ O		D	D	D	D	D	D	D	D	D	D	D

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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												
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 ₂ O												
Emissions	kt	0.000016	0.0000145	0.0000131	0.0000117	0.0000104	0.0000092	0.0000087	0.0000081	0.0000075	0.0000069	0.0000063
Plants	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Effluent	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
NM VOC	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 ₂ O	kg N ₂ O-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. Domestic wastewater: 5. Waste > 5.D. Wastewater treatment and discharge > 5.D.1. Domestic wastewater (Part 3 of 3)

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
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	0.035
Sludge removed	kt DC	NO	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	NO
Method													
CH ₄		T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
N ₂ O		T1	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	D
N ₂ O		D	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	0.298
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	0.011

Description	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Amount of CH ₄ flared	kt	NO	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
N ₂ O													
Emissions	kt	0.0000051	0.0000039	0.0000026	0.0000013	NO	NO	NO	NO	NO	NO	NO	NO
Plants	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Effluent	kt	0.0000051	0.0000039	0.0000026	0.0000013	NO	NO	NO	NO	NO	NO	NO	NO
NO _x	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NM VOC	kt	NE	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	0.3
N ₂ O	kg N ₂ O-N/kg N	0.005	0.005	0.005	0.005	NO	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 synthetic nitrogen fertilisers and organic fertiliser mostly deposited by animal onto pasture. The main type of synthetic nitrogen fertiliser used in New Zealand is urea, which is both manufactured in New Zealand and imported. Smaller amounts of diammonium phosphate (DAP) and ammonium sulphate are used. Nitrogen fertilisers are 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 (N₂O) (see figure 5.5.1 in chapter 5). Urea also releases carbon dioxide (CO₂).

Currently the Agriculture inventory model assumes emissions from organic fertilisers come mainly 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).

A small proportion of emissions from organic fertilisers come from sources other than manure. Sources include dairy processing wastewater, compost sold to the rural sector, meat processing wastewater, grape marc, vegetable processing wastewater and sewage sludge applied to land.

Emissions of N₂O from all synthetic (including urea) nitrogen fertilisers are reported in categories 3.D.1.1 and 3.D.1.2 respectively. Emissions of CO₂ from urea are not included under synthetic nitrogen fertilisers and are reported under a dedicated category 3.H.

In New Zealand, lime and dolomite fertilisers are mainly applied to acidic grassland and cropland soils to reduce soil acidity and maintain or increase production of pasture and crops. Emissions of CO₂ from liming are reported under a dedicated category 3.G.

2023

In 2023, the combined effect of synthetic and organic nitrogen fertilisers totalled 22.6 per cent of emissions from the *Agricultural soils* category and 3.5 per cent of total agricultural emissions. Carbon dioxide emissions from urea and liming contribute a further 1.7 per cent (699.5 kilotonnes carbon dioxide equivalent (kt CO₂)) of total agricultural emissions.

Table A8.1.1 shows comparisons of both N₂O and CO₂ emissions from nitrogen and lime 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 2023

Fertiliser type	Gas and source	Emissions kt CO ₂ -e	Percentage of	
			N ₂ O emissions from Agriculture soils by gas (%)	All emissions from Agriculture (%)
Synthetic nitrogen fertiliser	Direct N ₂ O emissions	1,109.9	17.4	2.7
	Urea N ₂ O	656.0	10.3	1.6
	Other synthetic nitrogen fertilisers	453.9	7.1	1.1
	Indirect N ₂ O emissions from all synthetic nitrogen fertilisers	229.1	3.6	0.6
	All N ₂ O (direct + indirect) from synthetic nitrogen fertilisers	1,339.0	21.0	3.3
	CO ₂ from urea	425.7	NA	1.0
Organic fertiliser	Direct N ₂ O emissions	73.3	1.1	0.2
	Indirect N ₂ O emissions	26.0	0.4	0.1
	All N ₂ O (direct + indirect) from organic fertilisers	99.3	1.6	0.2
Lime and dolomite	CO ₂ from application of limestone and dolomite	273.8	NA	0.7

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

1990–2023

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 534.4 per cent, while organic fertiliser use has grown by 180.7 per cent (table A8.1.2).

Table A8.1.2 Use of fertilisers in New Zealand in 1990 and 2023

Fertiliser type	Application tonnes (N)	1990		Application tonnes (N)	2023		Change in the use between 1990 and 2023	
		Percentage of synthetic nitrogen fertiliser (%)	all fertilisers (%)		Percentage of synthetic nitrogen fertiliser (%)	all fertilisers (%)	tonnes (N)	(%)
Synthetic nitrogen fertiliser (ammonium phosphates, for example, DAP)	34,679.1	58.5	46.3	109,000.0	29.0	26.0	74,320.9	214.3
Urea	24,585.9	41.5	32.8	267,000.0	71.0	63.6	242,414.1	986.0
Total synthetic nitrogen fertilisers (urea + ammonium phosphates)	59,265.0	100.0	79.1	376,000.0	100.0	89.5	316,735.0	534.4
Organic fertilisers	15,682.0	NA	20.9	44,025.1	NA	10.5	28,343.1	180.7

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

Between 1990 and 2023, N₂O emissions from synthetic nitrogen fertiliser (both direct and indirect emissions, including urea) have increased by 447.2 per cent, while total emissions from these fertilisers (N₂O and CO₂) have increased by 521.6 per cent. For the same period, total emissions from organic fertilisers increased by 140.5 per cent (see table A8.1.3).

In 1990 and 2023 respectively, 0.7 per cent and 3.3 per cent of total agricultural emissions originated from N₂O from synthetic nitrogen fertiliser. Total emissions from synthetic nitrogen fertiliser (including CO₂ from urea) have increased from 0.8 per cent to 4.3 per cent of total agricultural emissions for 1990 and 2023 respectively (see chapter 5, for further details).

Table A8.1.3 Emissions from fertilisers in 1990 and 2023

			Synthetic nitrogen fertilisers	Organic fertilisers	Liming
1990	N ₂ O emissions	kt CO ₂ -e	244.7	41.3	NA
	CO ₂ emissions	kt CO ₂	39.2	NA	296.5
	Total emissions	kt CO₂-e	283.9	41.3	296.5
2023	N ₂ O emissions	kt CO ₂ -e	1,339.0	99.3	NA
	CO ₂ emissions	kt CO ₂	425.7	NA	273.8
	Total emissions	kt CO₂-e	1,764.6	99.3	273.8
Change in N ₂ O emissions between 1990 and 2023		kt CO ₂ -e	1,094.3	58.0	NA
Percentage change in N ₂ O emissions between 1990 and 2023		%	447.2	140.5	NA
Change in all emissions between 1990 and 2023		kt CO ₂ -e	1,480.8	58.0	-22.7
Percentage change in all emissions between 1990 and 2023		%	521.6	140.5	-7.7

Note: NA = not applicable.

A8.2 Agricultural livestock emissions by livestock type

This section covers the distribution of all livestock greenhouse gas emissions from the Agriculture sector by livestock type in 1990, 2022 and 2023, including the changes in emissions. Table A8.2.1 shows total emissions of all greenhouse gases across all livestock 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, 2022 and 2023

Livestock type	1990	2022	2023	1990–2023		2022–2023	
			kt CO ₂ -e	kt CO ₂ -e	(%)	kt CO ₂ -e	(%)
Dairy cattle	8,713.3	19,942.1	1,9613.9	10,900.6	125.1	-328.2	-1.6
Beef cattle	8,488.0	8,303.2	8,175.3	-312.7	-3.7	-127.8	-1.5
Sheep	17,366.4	9,586.7	9,292.2	-8,074.2	-46.5	-294.6	-3.1
Deer	505.5	485.1	458.6	-46.9	-9.3	-26.5	-5.5
Swine	93.5	66.0	59.8	-33.7	-36.0	-6.2	-9.3
Goats	280.6	28.1	24.8	-255.8	-91.2	-3.3	-11.7
Horses	80.9	28.9	26.8	-54.0	-66.8	-2.0	-7.0
Alpaca	0.1	4.3	4.5	4.3	3,790.0	0.1	2.8
Mules and asses	0.7	0.7	0.7	0.0	0.0	0.0	0.0
Poultry (including all types of poultry)	24.8	52.4	52.6	27.8	111.8	0.2	0.3
Total, all livestock types	35,553.8	38,497.5	37,709.2	2,155.4	6.1	-788.3	-2.0

Note: Columns may not add up due to rounding.

Annex 9: Land Use, Land-Use Change and Forestry (LULUCF) accounting under the Paris Agreement

A9.1 General information

A9.1.1 Context

This annex describes New Zealand's approach to accounting for greenhouse gas emissions from the Land Use, Land-Use Change and Forestry (LULUCF) sector towards its first Nationally Determined Contribution (NDC1) under the Paris Agreement. New Zealand's progress towards NDC1 is formally reported every two years in a biennial transparency report. This annex is not a mandatory part of the New Zealand Greenhouse Gas Inventory but is additional information to provide an annual update of LULUCF accounting quantities.

New Zealand's accounting approach for the LULUCF sector recognises additional action. This approach creates incentives for the establishment of new forests, recognises permanent, long-term enhancements of carbon sinks resulting from forest management activities, and takes responsibility for deforestation, while accommodating the long-term cycles in net emissions and removals that arise from management of production forests.

New Zealand applies an activity-based accounting approach to the net emissions accounted for from the LULUCF sector for NDC1. New Zealand accounts for emissions from the following LULUCF activities: *Afforestation and reforestation*, *Deforestation* and *Forest management*. The methods applied to estimate accounting quantities adhere to the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (2006 IPCC Guidelines) (IPCC, 2006b) and the 2013 Kyoto Protocol Supplement (IPCC, 2014). The methods take a country-specific approach to account for emissions from *Afforestation and reforestation* activities, as communicated in New Zealand's NDC1.¹¹

Afforestation and reforestation activities

To address the effects of age-class structure and account only for the long-term additional carbon sequestered in forests established from the activity start year (1990), these forests are accounted for up until they attain their long-term average (LTA) carbon stock. No further carbon gains or losses are accounted for once these forests reach their LTA, taking into account all carbon pools and activities. The net emissions from these forests above the LTA are instead tracked separately to quantify deviations from an emissions pathway consistent with attaining the LTA carbon stock. Emissions and removals from these forests will balance out to the LTA under business-as-usual management over time. Emissions and removals from *Afforestation and reforestation* activities will be reconciled against the LTA, to ensure it accurately reflects the long-term removals being accounted for from these activities at the end of the accounting period covered by NDC1. This may include a recalculation of the LTA to reflect actual harvest rates occurring during the accounting period.

¹¹ Submission under the Paris Agreement New Zealand's first Nationally Determined Contribution Updated 4 November 2021.

Deforestation activities

New Zealand continues to fully account for emissions from all deforestation activities.

Forest management activities

To address the effects of age-class structure, forests established before the activity start year (1990) are accounted for against a business-as-usual reference level. For planted forests, the reference level addresses the dynamic effects of age-class structure resulting from activities and practices before the reference year, and the ongoing cycles of forest harvest and regrowth that occur as part of normal forest management in production forests.

Natural disturbances and harvested wood products

Accounting provisions to address natural disturbances on managed lands, non-anthropogenic effects and additionality since the activity start year are applied, building on existing guidance. Accounting for harvested wood products (HWP) is based on the production approach.

A9.1.2 Emissions summary

New Zealand's net emissions from LULUCF activities for the period reported to date

Net emissions from and area of land subject to *Afforestation and reforestation*, *Forest management* and *Deforestation* activities are provided for the years 2021 to 2023 in kilotonnes carbon dioxide equivalent (kt CO₂-e) respectively (table A9.1.1). Note these are not the accounting quantities for these activities. Accounting quantities are presented in table A9.1.3.

Table A9.1.1: Net emissions and area by activity

		2021	2022	2023
Afforestation and reforestation	Net cumulative area since 1990 (ha)	825,691	908,901	989,958
	Area in calendar year (ha)	55,185	86,385	83,423
	Net emissions (kt CO₂-e)	-11,012.8	-8,745.2	-7,766.8
Deforestation	Net cumulative area since 1990 (ha)	236,917	240,908	244,138
	Area in calendar year (ha)	4,752 ^P	3,991 ^P	3,230 ^P
	Net emissions (kt CO₂-e)	3,126.0	2,347.4	1,790.3
Forest management	Area included (ha)	9,186,362	9,185,546	9,184,681
	Net emissions (kt CO₂-e)	-18,145.6	-18,433.2	-19,793.2
Total area included (ha)		10,248,970	10,335,355	10,418,777
Total net emissions in calendar year (kt CO₂-e)		-26,032.4	-24,831.0	-25,769.7

Note: P = provisional value. Where net emissions result in removals, they are expressed as a negative value as per section 2.2.3 of the 2006 IPCC Guidelines (IPCC, 2006b). Columns may not total due to rounding.

Net emissions from *Afforestation and reforestation* activities include:

- net emissions from the growth of forest established during or after 1990 (post-1989 forests)
- emissions from the decay of post-1989 forest harvest residues
- emissions and removals from HWP derived from post-1989 forests
- emissions from the conversion of land to post-1989 forest (biomass losses from previous land use and soil carbon changes)
- carbon dioxide (CO₂) emissions from biomass burning
- emissions associated with changes in soil carbon.

Net emissions from *Deforestation* activities include:

- emissions from deforestation of all forest land. This includes deforested pre-1990 planted forests, post-1989 forests and pre-1990 natural forests
- biomass and soil emissions and removals from the conversion of forest to another land use.

Net emissions from *Forest management* activities include:

- net emissions from the growth of forests that existed on 31 December 1989 that have not been deforested (pre-1990 forests)
- emissions from harvesting of pre-1990 forests
- emissions from the decay of pre-1990 forest harvest residues
- emissions and removals from HWP derived from pre-1990 forests
- CO₂ emissions from biomass burning
- emissions from the drainage of managed soils on land classified under *Forest management*
- emissions associated with changes in soil carbon from the conversion between pre-1990 natural and planted forest types.

Non-CO₂ emissions are incorporated in the emissions totals for each activity and include:

- emissions from biomass burning
- emissions from the mineralisation of soil nitrogen and the emissions from the drainage of managed soils associated with afforestation, reforestation or deforestation activities since 1990.

Note that annual net emissions reported here are around 1.7 megatonnes (Mt) CO₂-e lower than the corresponding emissions reported in volume 1, chapter 6. This is due to differences in what is reported in the HWP pool and what is accounted for. In the case of *Forest management*, emissions from HWP originating from forests harvested before 2013 are excluded as are the HWP derived from wood originating from *Deforestation* activities. This is in line with the 2013 Kyoto Protocol Supplement (IPCC, 2014). For further information, see section A9.3.5.

New Zealand's net greenhouse gas emissions by gas type for each LULUCF activity for the period reported to date

Table A9.1.2 provides a breakdown of New Zealand's net emissions for 2021 to 2023, by greenhouse gas type for the LULUCF activities accounted for towards New Zealand's NDC1. Note these are not the accounting quantities for these activities, which are presented in table A9.1.3.

Table A9.1.2: Annual net emissions by greenhouse gas volume (kt) and by greenhouse gas equivalence (CO₂-e) for each activity, for 1 January 2021 to 31 December 2023

Year	Activity	Source emissions (kt)			Emissions (kt CO ₂ -e)			Total
		CO ₂	N ₂ O	CH ₄	CO ₂	N ₂ O	CH ₄	
2021	Afforestation and reforestation	-11,120.1	0.4	0.2	-11,120.1	102.8	4.5	-11,012.8
	Deforestation	3,102.0	0.0	0.5	3,102.0	10.7	13.3	3,126.0
	Forest management	-18,213.8	0.2	0.4	-18,213.8	56.6	11.5	-18,145.6
	Total net emissions				-26,232.0	170.2	29.4	-26,032.4
2022	Afforestation and reforestation	-8,866.5	0.4	0.2	-8,866.5	116.0	5.4	-8,745.2
	Deforestation	2,326.6	0.0	0.4	2,326.6	9.6	11.2	2,347.4
	Forest management	-18,500.3	0.2	0.4	-18,500.3	56.4	10.7	-18,433.2
	Total net emissions				-25,040.3	182.1	27.2	-24,831.0
2023	Afforestation and reforestation	-7,903.0	0.5	0.3	-7,903.0	128.9	7.3	-7,766.8
	Deforestation	1,773.6	0.0	0.3	1,773.6	8.2	8.4	1,790.3
	Forest management	-19,870.0	0.2	0.7	-19,870.0	56.9	19.9	-19,793.2
	Total net emissions				-25,999.4	194.0	35.7	-25,769.7

Note: Columns may not total due to rounding.

A9.1.3 Accounting summary

New Zealand's LULUCF accounting quantities for NDC1 will be provisional until they are finalised at the end of the accounting period. The accounting quantities comprise:

1. net emissions from the growth of *Afforestation and reforestation* forests up to their LTA carbon stock
2. net emissions from *Deforestation*
3. net emissions from *Forest management* activities relative to a pre-1990 forest reference level (FRL). The pre-1990 FRL is set using a business-as-usual projection of emissions for *Forest management* activities over the period to 2030. It represents the estimated annual average net emissions between 2021 and 2030.

The provisional LULUCF accounting quantities reported in this submission, and shown in table A9.1.3, comprise net emissions from the growth of *Afforestation and reforestation* forests up to their LTA carbon stock and all net emissions from *Deforestation*, but do not include net emissions from *Forest management*. This is because the pre-1990 FRL is calculated as an annual average and will fluctuate on an interannual basis but is expected to even out across the time series. It is likely to require technical corrections in future years to account for the reduction in the total forest area occurring as a result of deforestation (to avoid double-counting deforestation emissions) and to maintain methodological consistency with inventory estimates. New Zealand's Biennial Transparency Report, covering the full NDC1 period (i.e., the fifth Biennial Transparency Report), will include the final accounting quantities from *Forest management* activities.

Net emissions and the provisional accounting quantities by activity, along with the total provisional accounting quantities (excluding the contribution from *Forest management*) that are claimed towards NDC1 for the years 2021 to 2023, are provided in table A9.1.3.

Table A9.1.3: New Zealand's provisional accounting quantities for 2021 to 2023

		Emissions (kt CO ₂ -e)			
		2021	2022	2023	Total
Net emissions by activity					
Afforestation and reforestation		-11,012.8	-8,745.2	-7,766.8	-27,524.8
Deforestation		3,126.0	2,347.4	1,790.3	7,263.7
Forest management		-18,145.6	-18,433.2	-19,793.2	-56,372.0
Total net emissions in calendar year		-26,032.4	-24,831.0	-25,769.7	-76,633.0
Excluded emissions from natural disturbances		-	-	-	-
Provisional accounting quantities by activity					
Afforestation and reforestation	Below long-term average accounting emissions	-9,228.8	-7,705.0	-7,069.9	-24,003.7
	Cumulative emissions	-9,228.8	-16,933.7	-24,003.7	-24,003.7
Deforestation	Deforestation	3,126.0	2,347.4	1,790.3	7,263.7
	Cumulative emissions	3,126.0	5,473.4	7,263.7	7,263.7
Forest management	Reference level	-20,134.9	-20,134.9	-20,134.9	-60,404.7
	Annual emissions against reference level	1,989.3	1,701.7	341.7	4,032.7
	Cumulative emissions against reference level	1,989.3	3,691.0	4,032.7	4,032.7
Accounting quantities	Emissions excl. Forest management	-6,102.8	-5,357.6	-5,279.6	-16,739.9
	Cumulative emissions excl. Forest management	-6,102.8	-11,460.3	-16,739.9	-16,739.9

A9.1.4 Definitions of Forest land

New Zealand uses the same *Forest land* definition in accounting for NDC1 as that used in inventory submissions and for previous accounting under the Kyoto Protocol. These provide minimum values for land area, crown cover and height. New Zealand also applies a minimum value for forest width, which excludes linear shelterbelts from the *Forest land* category. Linear shelterbelts can vary in width and height, because they are periodically trimmed and topped. Further, they form part of non-forest land use, namely *Cropland* and *Grassland*, as shelter for crops and/or animals. Table A9.1.4 provides the defining parameters for *Forest land*.

Table A9.1.4: Parameters defining *Forest land* in New Zealand

Forest parameter	New Zealand selected value
Minimum land area (ha)	1
Minimum crown cover (%)	30
Minimum height (m)	5
Minimum width (m)	30

For reporting under the Paris Agreement and United Nations Framework Convention on Climate Change, New Zealand has categorised its forests into four types: pre-1990 natural forest, pre-1990 planted forest, post-1989 natural forest and post-1989 planted forest. Post-1989 planted forest is subdivided into production forest – planted for wood supply and undergoing a regular cycle of harvesting and replanting, and permanent forest – planted for carbon storage and/or for other ecosystem services, such as erosion control.

For all post-1989 forests that have not been deforested, emissions and removals from carbon losses and gains (including emissions from harvesting of post-1989 forest) are reported under *Afforestation and reforestation* activities. These activities are further subdivided into *Afforestation and reforestation Below LTA* for forests with carbon stocks below the age when the long-term average carbon stock is reached, and *Afforestation and reforestation Above LTA* for post-1989 forests above the age when the long-term average carbon stock is reached.

Forests remain in the *Afforestation and reforestation Below LTA* category until the end of the year in which they reach the 'LTA age' (see section A9.3.2).

Emissions from deforestation events in all forest types are reported and accounted for under *Deforestation* activities.

For all pre-1990 forests that have not been deforested, emissions and removals from carbon losses and gains are reported under *Forest management* activities. Emissions and removals from the harvest and conversion of forest plantations and establishment of new forests that satisfy the definition of carbon equivalent forests, as specified in section 2.7.7.2 of the 2013 Kyoto Protocol Supplement (IPCC, 2014), are reported under *Forest management*.

The definition of forest used for reporting to the Food and Agriculture Organization is currently different from that used for reporting under the United Nations Framework Convention on Climate Change and the Paris Agreement. For reporting to the Food and Agriculture Organization, New Zealand has subdivided forests into two estates based on their biological characteristics, the management regimes applied to the forests and their respective roles and national objectives (Ministry of Agriculture and Forestry, 2002). The two estates are indigenous and planted production forest. The indigenous estate is included within the pre-1990 natural forest as reported in this submission. The planted production forest area largely equates to the productive area in pre-1990 planted forest and post-1989 planted forest.

A9.1.5 Activity tracking

In 2023, *Afforestation and reforestation*, *Deforestation* and *Forest management* activities covered 10,418,777 hectares, or 38.7 per cent, of New Zealand's total land area.

Allocation of land parcels to the correct activity is achieved by tracking areas during the processes of land use mapping and emissions calculation.

Once a forest area has been identified as deforested, it remains reported in this category. Therefore, all subsequent emissions and removals that occur on this land are reported under *Deforestation*. The process for identification of deforested land is outlined in section A9.5.2.

Areas subject to the carbon equivalent forest provision are also tracked through the land use mapping process and all emissions and removals that occur on this land are reported under *Forest management* (see section A9.2.2 and section A9.3.4, for more detail).

The emissions and removals that occur on areas of land subject to Afforestation and reforestation activities are reported in the *Afforestation and reforestation Below LTA* subcategory until the end of the year that they reach their LTA. All subsequent emissions and removals from these activities are reported in the *Afforestation and reforestation Above LTA* subcategory.

Table A9.1.5 shows the movement of land between activity categories from 1 January 2023 to 31 December 2023.

Table A9.1.5: Area changes between activity categories between 1 January 2023 and 31 December 2023 (kha)

To 31 Dec 2023	From 1 Jan 2023					Area as at 31 Dec 2023
	A & R Below LTA	A & R Above LTA	Deforestation	Forest management	Inventory only*	
A & R Below LTA	559.4	-	-	-	83.4	642.8
A & R Above LTA	27.5	319.6	-	-	-	347.2
Deforestation	0.6	1.7	240.9	0.9	-	244.1
Forest management	-	-	-	9,184.7	-	9,184.7
Inventory only*	-	-	-	-	16,506.3	16,506.3
Area as at 1 Jan 2023	587.5	321.4	240.9	9,185.5	16,589.7	26,925.1
Net change 1 Jan 2023–31 Dec 2023	55.2	25.8	3.2	-0.9	-83.4	0.0
Net change 1 Jan 2023–31 Dec 2023 (%)	9.4	8.0	1.3	-0.0	-0.5	0.0

Note: A & R = Afforestation and reforestation; LTA = long-term average; inventory only* refers to non-forest land that is included in New Zealand's Greenhouse Gas Inventory of all land-based emissions but is not eligible for inclusion in the activities accounted for in New Zealand's NDC1.

A9.2 Land-related information

A9.2.1 Spatial assessment unit

New Zealand is using a minimum mapping unit of 1 hectare.

A9.2.2 Methodology for land transition matrix

The land transition matrix is derived from a combination of:

- wall-to-wall land use mapping completed every five years
- deforestation mapping completed every two years
- forest survey data
- interpolation and extrapolation of trends to obtain annual land transitions.

For the period from 1990 to 2023, land transitions are derived from the following data sources:

- the 1990, 2008, 2012, 2016 and 2020 land use maps
- an estimate of total afforestation for planted forest for 2017 to 2023 is based on the National Exotic Forest Description (NEFD) (Ministry for Primary Industries, 2024b)
- the annual area of afforestation of post-1989 natural forest for 2017 to 2021 is estimated from the Ministry for Primary Industries afforestation scheme data
- the area of post-1989 natural afforestation for 2022 and 2023 is estimated from the *Afforestation and Deforestation Intentions Survey* for 2023 by taking the total area of 'natural reversion' and 'indigenous tall planted' (Manley, 2024)
- 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 2023
- deforestation mapping for 2008 to 2020
- estimates of 2021, 2022 and 2023 planted forest deforestation based on extrapolation of the planted forest deforestation trend occurring over the period 2014 to 2020

- estimates of 2021, 2022 and 2023 natural forest deforestation calculated as the average of the three previous mapped years (2017 to 2020).

Due to the land use category definitions used by New Zealand, which split forests established before 1990 from those established after 1989 (section A9.1.4), the land transition matrix is derived from the sequence of land-use changes occurring through the reporting period. Using the 1990 land use map as the baseline, areas of deforestation are tracked through time to ensure that, regardless of subsequent land-use change, the net emissions that occur on the deforested land are reported under *Deforestation*. Where a pre-1990 planted forest is harvested and converted to another land use under the carbon equivalent forest provision, the land is tracked spatially and its net emissions are reported under *Forest management*, as are the areas and net emissions due to the new forest that was established to compensate for the harvested and converted forest.

The relationship between mapped land-use changes and activities reported under *Afforestation and reforestation*, *Deforestation* and *Forest management* is shown in table A9.1.6.

Table A9.1.6: Relationship between mapped land-use changes and LULUCF activities accounted for towards NDC1

Final Initial	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 forest	Grassland	Cropland	Wetland	Settlements	Other land
Pre-1990 natural forest	FM	FM	NA	D	D	D	D	D
Pre-1990 planted forest	FM	FM	NA	D/FM	D/FM	D/FM	D/FM	D/FM
Post-1989 forest	NA	NA	A	D	D	D	D	D
Grassland	*D	*D	A/FM					
Cropland	*D	*D	A/FM					
Wetland	*D	*D	A/FM					
Settlements	*D	*D	A/FM					
Other land	*D	*D	A/FM					

Note: A = *Afforestation and reforestation*; A/FM indicates that a forest establishment activity could be accounted for under *Forest management* if the land is subject to the carbon equivalent forest provision; D = *Deforestation*; '*D' denotes land-use changes that are valid only if the land was forested at 1990, in which case the land use transition is accounted for under deforestation (e.g., pre-1990 planted forest converted to grassland since 1990 that is later converted back to pre-1990 planted forest would be reported under *Deforestation*); D/FM indicates that a forest harvest and conversion activity could be accounted for under *Forest management* if the land is subject to the carbon equivalent forest provision; FM = *Forest management*; 'NA' denotes land-use changes that are not applicable given the land use definitions.

Further information on the mapping of land-use change and the estimation of the total area of afforested and reforested land occurring between 1990 and 2023 can be found in annex 5, section 5.2.

Accurate classification of pre-1990 forest is essential to correctly determine the area reported as afforested and reforested in the land transition matrix. Satellite imagery at various dates near to 1990 and mapping from the New Zealand Emissions Trading Scheme (NZ ETS) have been used to ensure these forests are classified correctly. This process is also shown in annex 5, section 5.2.

Transitions to *Deforestation* are based on deforestation mapping to 2021 and estimates of deforestation by forest type for 2022 and 2023. In both cases, the identification of the forest type allows the transitions from *Afforestation and reforestation* (post-1989 forest) and *Deforestation* and *Forest management* (pre-1990 forest) to *Deforestation* to be identified.

A9.2.3 Identifying geographical locations

New Zealand uses wall-to-wall mapping, completed every four to five years, with national statistics and ancillary mapping data in the intervening years to estimate afforested, reforested and deforested land areas.

Included in New Zealand's geographical extent are the following uninhabited offshore islands: Kermadec Islands, Three Kings Islands and subantarctic islands (Auckland Islands, Campbell Island, Antipodes Islands, Bounty Islands and Snares Islands). These islands are protected conservation sites with a total land area of 74,052 hectares. They are not subject to land-use change and are therefore reported in a steady state of land use.

A9.3 Activity-specific information

A9.3.1 Estimating carbon stock change

Emissions and removals from *Afforestation and reforestation*, *Deforestation* and *Forest management* activities are estimated using the Land Use and Carbon Analysis System (LUCAS) forest plot network for each type of forest (pre-1990 natural forest, pre-1990 planted forest, post-1989 planted forest and post-1989 natural forest). Carbon analyses are performed to estimate the carbon stored per hectare per pool and are described in volume 1, chapter 6, section 6.1.2 and section 6.4.2. For planted forests, yield tables are derived from the forest plot data (Paul et al, 2024). Survey and scheme data (Manley, 2024; Ministry for Primary Industries, 2024b) provide other important inputs to model forest age, harvest age and harvest age profiles (see annex 5, section A5.2.5).

A9.3.2 Afforestation and reforestation

Between 1990 and 2023, it is estimated that 1,053,838 hectares of new forest (post-1989 forest) were established as a result of *Afforestation and reforestation* activities (table A9.3.1). The net area of post-1989 forest (calculated from the total area of new forest planted since 31 December 1989 minus the deforestation of post-1989 forest since 1 January 1990) as at the end of 2023 was 989,958 hectares. Of the total area afforested or reforested between 1990 and 2023, an estimated 63,879 hectares were deforested (table A9.3.1). The emissions for this area are reported under *Deforestation*.

Table A9.3.1: New Zealand's estimated annual area (hectares)* under *Afforestation and reforestation* from 1990 to 2023

Year	Post-1989 planted forest		Post-1989 natural forest	Harvesting	Deforestation	Net cumulative area
	Production	Permanent				
1990	12,905	814	977	-	-	14,696
1991	12,587	793	1,140	-	-	29,216
1992	41,082	2,585	1,303	-	-	74,186
1993	50,360	3,172	1,140	-	-	128,859
1994	80,298	5,057	977	-	-	215,191
1995	60,484	3,806	814	-	-	280,295
1996	68,539	4,305	814	-	-	353,954
1997	52,186	3,280	2,609	-	-	412,030
1998	41,878	2,637	2,932	-	-	459,476
1999	32,720	2,060	3,257	-	-	497,513
2000	27,594	1,730	4,072	-	-	530,909
2001	24,603	1,550	4,886	-	-	561,949

Year	Post-1989 planted forest		Post-1989 natural forest	Harvesting	Deforestation	Net cumulative area
	Production	Permanent				
2002	18,053	1,138	3,909	-	820	584,228
2003	16,255	1,025	4,397	-	2,586	603,318
2004	8,658	546	5,863	-	2,376	616,009
2005	4,931	309	6,840	200	2,703	625,386
2006	2,124	134	7,818	500	2,317	633,144
2007	1,960	124	7,329	500	5,562	636,995
2008	2,606	168	1,741	643	1,189	640,322
2009	5,870	381	1,698	756	2,075	646,195
2010	8,190	532	1,698	1,232	1,786	654,829
2011	16,379	1,064	1,698	1,384	2,289	671,682
2012	15,697	1,020	1,698	1,338	1,758	688,338
2013	5,887	377	1,989	3,030	2,950	693,642
2014	4,440	288	1,986	2,403	3,527	696,828
2015	4,443	288	1,986	3,641	2,809	700,736
2016	2,124	136	1,986	5,632	3,936	701,046
2017	4,638	301	4,661	10,153	4,648	705,999
2018	5,485	356	3,852	14,985	4,886	710,807
2019	19,548	1,269	5,465	17,329	2,691	734,398
2020	35,964	2,336	5,238	18,469	4,782	773,154
2021	47,996	3,118	4,071	18,613	2,648 ^P	825,691
2022	74,702	4,853	6,829	20,575	3,175 ^P	908,901
2023	73,142	4,751	5,529	21,972	2,365 ^P	989,958
Total	884,330	56,305	113,203	143,355	63,879	989,958

Note: P = provisional value; + = gross area including forestry roads and other unstocked areas in forestry land use. Columns may not total due to rounding. Net cumulative area represents the total cumulative forest area under *Afforestation and reforestation* in any given year including additions for areas of new planting and subtractions for areas of deforestation. The area of harvest does not contribute to the annual change in net cumulative forest area.

Averaging accounting approach

Emissions and removals from *Afforestation and reforestation* activities are accounted for until the forests attain their LTA carbon stock, taking into account all carbon pools. Thereafter, emissions and removals from these activities are tracked to ensure emissions and removals balance out over the long term under business-as-usual management.

At the end of NDC1, the actual emissions from *Afforestation and reforestation* activities will be reconciled with the emissions included in the averaging approach. Further work is planned to determine whether this will be done via a post-1989 FRL or by recalculating the LTA carbon stock at the end of the accounting period.

The LTA carbon stock is defined as the long-term average carbon stock per hectare that would be maintained (on average) across all biomass carbon pools under current management conditions. For planted forests managed under a clear-fell rotation regime (rotational planted forests), the LTA carbon stock refers to the carbon stocks of all carbon pools when averaged out over multiple rotations under current management. This includes the HWP pool resulting from the harvest of these forests. The 'LTA age' is the age at which this long-term average carbon stock is achieved, which is assumed to be an equilibrium point about which future losses and gains balance out to zero over subsequent harvest and replanting cycles, as long as current management continues.

For forests that do not undergo harvesting, such as post-1989 permanent planted forests and post-1989 natural forests, the LTA age is assumed to be over 40 years, therefore they will remain in the *Below LTA* subcategory throughout NDC1 (Wakelin and Paul, 2024a).

By contrast, post-1989 rotational planted forests, which include various species with different average rotation lengths (table A9.3.2), have a combined LTA age of 23 years and transition from the *Below LTA* subcategory to the *Above LTA* subcategory at the end of their 23rd year. This age has been estimated in an LTA model that calculates carbon stock changes over eight rotations (Dovey and Wakelin, unpublished). This model takes the following inputs:

- forest management and growth rates for three separate species groupings: radiata pine, Douglas fir and other softwoods, and hardwoods, each represented by yield tables derived from the LUCAS forest plot network (Paul et al, 2024)
- proportions of species groups, from the LUCAS post-1989 forest plot network
- harvest age, derived from a combination of national forest survey data and industry studies (Ministry for Primary Industries, 2024b)
- lifespan of wood products and discard curves from New Zealand’s HWP model (Wakelin, unpublished(a))
- proportion of domestically processed and exported roundwood and allocation of roundwood to different export markets (defined as the average over five years of available data, 2018 to 2022; Dovey and Wakelin, unpublished)
- decay rates for woody debris used in the LUCAS Calculation and Reporting Application (CRA) (volume 1, chapter 6).

Table A9.3.2: Estimated average harvest age and proportion of forest species included in the rotational plantation forest long-term average

Forest species	Estimated average harvest age (years)	Proportion (%)
Radiata pine	28	82.4
Douglas fir and other softwoods	40	11.6
Hardwoods	30	5.8

The underlying principle of the LTA is that, although the carbon stock of a forest and its associated wood products may fluctuate over time with harvesting and replanting, an LTA carbon stock can be calculated that represents a net change in stock compared with the pre-existing carbon levels before afforestation (Wakelin et al, unpublished).

Following this principle of crediting forest growth up to the calculated LTA age, an accounting adjustment is made for forests harvested before and after the LTA age is reached. This adjustment effectively grows the harvested forest on to the LTA age and removes forests harvested above the LTA age.

The rationale for this adjustment is as follows.

1. All harvest emissions have implicitly been included in the calculation of the LTA carbon stock and age.
2. This early harvest is considered to be ad hoc rather than due to a short rotation forest crop within the *Afforestation and reforestation* forest estate. Therefore, across multiple rotations of these forests, it is appropriate to credit growth to the full LTA carbon stock.
3. Forests are harvested across an age profile centred on the average harvest age, which means that some area is also harvested above the average harvest age. The averaging approach means that the extra growth from this ‘late’ harvest is not credited. To balance

accounting for both early and late harvest events, all forests need to be credited for growth up to the LTA age (see annex 5, section A5.2.5, for further information on harvest age profiling).

Table A9.3.3 shows the total area of post-1989 planted forest in each of the LTA subcategories by year of establishment and forest type. All permanent forests established after 1989 are considered to be below the LTA for the reporting period. Further work is planned to determine the permanent forest LTA, however, it is currently estimated to be more than 40 years, putting it beyond the NDC1 period for forests planted after 1989 (Wakelin and Paul, 2024a).

Table A9.3.3: Area (hectares) of permanent and production planted forests established after 1989 by long-term average subcategory on 31 December 2023

Year	Production forest		Permanent forest	
	Area below LTA	Area above LTA	Area below LTA	Net cumulative area
1990	12,905	-	814	13,718
1991	25,492	-	1,607	27,098
1992	66,574	-	4,192	70,766
1993	116,935	-	7,364	124,299
1994	197,232	-	12,421	209,653
1995	257,717	-	16,227	273,944
1996	326,256	-	20,532	346,788
1997	378,442	-	23,812	402,254
1998	420,320	-	26,449	446,769
1999	453,040	-	28,509	481,549
2000	480,634	-	30,239	510,873
2001	505,237	-	31,789	537,027
2002	522,470	-	32,927	555,397
2003	536,138	-	33,952	570,090
2004	542,420	-	34,498	576,918
2005	544,647	-	34,807	579,454
2006	544,454	-	34,941	579,395
2007	540,853	-	35,065	575,917
2008	542,283	-	35,233	577,516
2009	546,133	-	35,614	581,747
2010	552,575	-	36,146	588,721
2011	566,755	-	37,210	603,965
2012	580,754	-	38,230	618,984
2013	583,806	-	38,607	622,413
2014	578,590	6,256	38,895	623,742
2015	574,529	12,090	39,184	625,802
2016	542,975	41,990	39,320	624,285
2017 ^P	505,217	79,845	39,621	624,683
2018 ^P	442,280	143,610	39,978	625,869
2019 ^P	409,451	193,418	41,247	644,115
2020 ^P	386,945	247,231	43,583	677,758
2021 ^P	390,894	288,787	46,700	726,382
2022 ^P	430,001	321,365	51,553	802,919
2023 ^P	475,120	347,180	56,305	878,605

Note: P = provisional value. Because the long-term average (LTA) age is estimated to be 23 years, no area of *Afforestation and reforestation* can enter the Above LTA subcategory before 2013.

New Zealand estimates emissions from HWP originating from *Afforestation and reforestation* activities. This is described further in section A9.3.5.

A9.3.3 Deforestation

All carbon stock changes and non-CO₂ emissions occurring on land areas subject to *Deforestation* activities that have occurred since 1990 are estimated when reporting net emissions from *Deforestation* activities. This includes the emissions resulting from the loss of carbon stored in the biomass before deforestation; soil carbon stock changes due to the land-use change, including lagged emissions from previous deforestation events; mineralisation of soil nitrogen associated with the land-use change; emissions from burning biomass associated with the land-use change; and the carbon stock changes from the increase in biomass pools on the new land use.

Between 1990 and 2023, it is estimated that 244,138 hectares of all forest types were subject to *Deforestation* activities. Table A9.3.4 shows the areas of *Forest land* subject to *Deforestation* activities since 1990 by forest category.

Table A9.3.4: Area (hectares) of New Zealand subject to deforestation

Year	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 planted forest	Post-1989 natural forest	Total	Cumulative total
1990	1,832	-	-	-	1,832	1,832
1991	1,832	-	-	-	1,832	3,663
1992	1,832	-	-	-	1,832	5,495
1993	1,832	-	-	-	1,832	7,327
1994	1,832	-	-	-	1,832	9,158
1995	1,832	-	-	-	1,832	10,990
1996	1,832	-	-	-	1,832	12,821
1997	1,832	-	-	-	1,832	14,653
1998	1,832	-	-	-	1,832	16,485
1999	1,832	-	-	-	1,832	18,316
2000	1,832	2,029	-	-	3,861	22,177
2001	1,832	1,946	-	-	3,778	25,955
2002	1,832	1,315	820	-	3,967	29,922
2003	1,832	2,893	2,586	-	7,311	37,233
2004	1,832	6,668	2,376	-	10,876	48,109
2005	1,832	13,678	2,703	-	18,213	66,321
2006	1,832	17,215	2,317	-	21,363	87,684
2007	1,837	22,842	5,562	-	30,240	117,925
2008	859	3,833	1,175	14	5,881	123,805
2009	2,537	5,583	2,020	55	10,196	134,001
2010	1,971	6,423	1,748	38	10,180	144,181
2011	1,164	5,384	2,200	89	8,838	153,019
2012	1,291	7,639	1,698	60	10,688	163,707
2013	1,207	9,742	2,835	115	13,899	177,606
2014	687	7,066	3,399	128	11,280	188,886
2015	1,022	4,613	2,671	139	8,444	197,330
2016	764	3,607	3,778	159	8,307	205,636
2017	509	2,463	4,542	106	7,621	213,257
2018	587	1,633	4,656	230	7,106	220,363

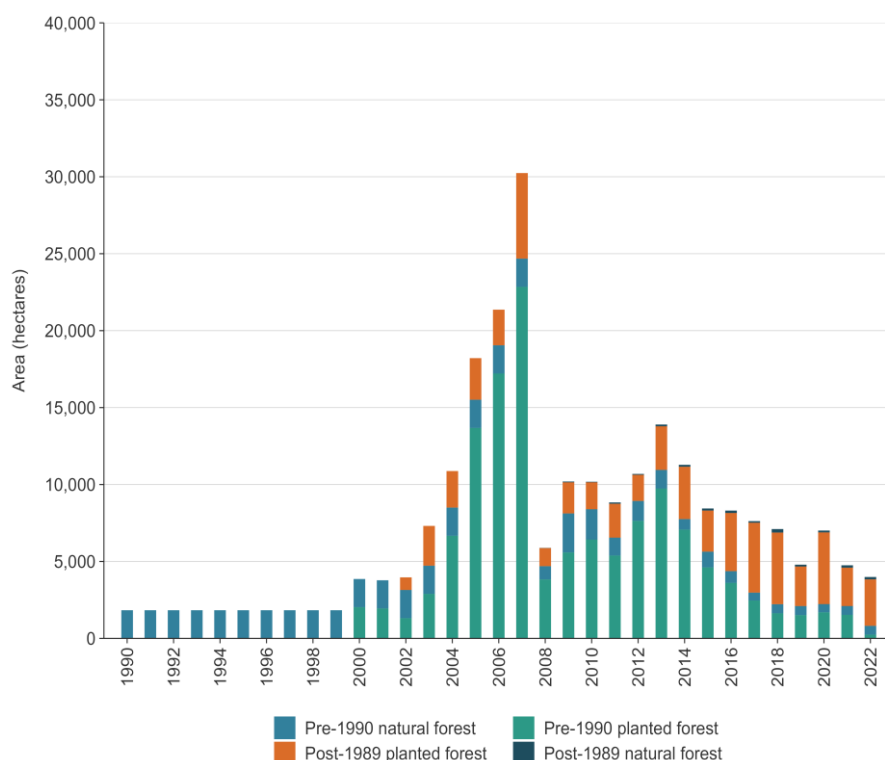
Year	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 planted forest	Post-1989 natural forest	Total	Cumulative total
2019	589	1,512	2,571	120	4,792	225,155
2020	535	1,694	4,657	125	7,011	232,166
2021 ^p	570	1,533	2,491	158	4,752	236,917
2022 ^p	570	245	3,018	158	3,991	240,908
2023 ^p	570	295	2,207	158	3,230	244,138

Note: P = provisional figures that will be updated once mapping is completed; areas are as at 31 December 2023. Deforestation differs from that reported in volume 1, chapter 6, due to the application of the carbon equivalent forests accounting provision and this table only recording the first deforestation event on any given area of land since 1990.

Figure A9.3.1 shows the annual areas deforested since 1990 by forest category. This shows the increase in pre-1990 planted forest deforestation that occurred in the four years leading up to 2008.

While the conversion of land from one land use to another is not uncommon in New Zealand, plantation forest deforestation on the scale seen between 2004 and 2008 was a new phenomenon. Most of the area of planted forest that was deforested from the mid-2000s onwards has subsequently been converted to grassland. This conversion is due in part to the relative profitability of some forms of pastoral farming (particularly dairy farming), compared with forestry, as well as the anticipated introduction of the NZ ETS.

Figure A9.3.1: New Zealand's annual areas of deforestation from 1990 to 2023



No deforestation of pre-1990 planted forest, post-1989 planted forest or post-1989 natural forest was estimated to have occurred between 1990 and 2000. Deforestation of these forest classes was not significant during this period and insufficient data exist to reliably report the small areas of deforestation that may have occurred.

Since the introduction of the NZ ETS in 2008, owners of pre-1990 planted forest have been able to deforest a maximum of 2 hectares in any five-year period without having to surrender emission units. Above this level of deforestation, pre-1990 planted forest owners are required to surrender units equal to the reported emissions, with some exemptions for smaller forest owners and tree weeds within protected areas (Ministry for Primary Industries, 2024b). Since 2007, a significant reduction has occurred in the rate of deforestation of pre-1990 planted forest. Post-1989 forest owners, who are registered in the NZ ETS, also have legal obligations to surrender units if the carbon stocks in their registered forest area fall below a previously reported level (e.g., due to deforestation, harvesting or fire).

It was expected that the level of deforestation during the first Kyoto Protocol commitment period (2008 to 2012) would be less than that seen before the introduction of the NZ ETS in 2008 (Manley, 2009). However, following the introduction of the NZ ETS, the carbon price went into a steady decline. The low carbon price reduced the liability on pre-1990 planted forest owners for deforestation. Consequently, more deforestation has occurred since 2008 than previously expected. Carbon prices have since increased, following the exclusion of international units from the scheme on 31 May 2015, an NZ ETS review and the passing of the Climate Change Response (Emissions Trading Reform) Amendment Act in 2020. This legislated major changes to the NZ ETS, including incentives for afforestation and the introduction of a unit cap to the scheme. These higher carbon prices are coincident with reduced deforestation activities.

The area of deforestation of pre-1990 natural forest before 2008 has been estimated by linear interpolation from the average land-use change mapped between 1 January 1990 and 1 January 2008. However, several factors suggest the rate of pre-1990 natural forest deforestation is unlikely to have been constant over the 18 years between 1990 and 2007, but instead mostly occurred before 2002. The area available for harvesting (and potentially deforestation) was higher before 1993 when amendments were made to the Forests Act 1949 that restricted natural forest harvesting. Further restrictions on the harvesting of natural forests were also introduced in 2002, resulting in the end of harvesting of publicly owned forests on the west coast of New Zealand's South Island from that time on. Both developments are likely to have reduced pre-1990 natural forest deforestation since 2002.

Further detail on the methods employed for estimating deforestation is provided in annex 5, section A5.2.1.

A9.3.4 Forest management

New Zealand applies the broad approach to interpreting the definition of forest management so that it includes the whole area classified as pre-1990 natural forest and pre-1990 planted forest. The area in this category excludes any area deforested since 1990, because this is reported under *Deforestation*, and includes areas to which the carbon equivalent forest accounting provision is applied.

The total area remaining in *Forest management* at the end of 2023 was 9,184,681 hectares; this is a decrease of 175,324 hectares (or 1.9 per cent) since 1990.

The source of the activity data and emission factors applied to *Forest management* activities is described in more detail in annex 5. This is because New Zealand applies the same methods to estimating emissions from *Forest management* activities as those applied to the equivalent inventory land use category, *Forest land remaining forest land*.

Where the land reported under *Forest management* has remained in the same land use category for more than 20 years, mineral soil carbon stocks are assumed to have reached steady state. New Zealand models the effects of land-use change on mineral soil carbon based on empirical measurements collected from each land use subdivision in steady state, specifically to model land-use change and management effects. The pre-1990 forests are subdivided into natural and planted forest types, which allows the different management methods to be taken into account.

Where organic soil is present on land reported under *Forest management* that is no longer in its natural state, the soil organic carbon pool is reported as an ongoing source of emissions.

Forest management activities are accounted for against the pre-1990 FRL. This means New Zealand is required to take responsibility for net emissions from *Forest management* activities when they exceed the pre-1990 FRL and conversely account for the additional sequestration when net emissions do not reach the pre-1990 FRL.

The pre-1990 FRL was set using a business-as-usual projection of net emissions from *Forest management* activities during NDC1 and represents the estimated annual average emissions over that period (see section A9.4.1, for further information).

Carbon equivalent forests

The carbon equivalent forests accounting provision allows pre-1990 planted forests that meet the conditions specified in section 2.7.7.2 of the 2013 Kyoto Protocol Supplement (IPCC, 2014) to be harvested and converted to another land use without being classified as deforested, provided a new forest that will reach carbon equivalence is established elsewhere. The carbon stock changes in New Zealand's carbon equivalent forests for 2021 to 2023 are summarised in table A9.3.5. A detailed list of individual applications is shown in table A9.3.6.

Table A9.3.5: Carbon equivalent forests from 2021 to 2023

		2021	2022	2023
Newly established	Area (ha)	-	-	-
	Net emissions (kt CO ₂)	-47.2	-92.5	-141.6
Harvested and converted	Area (ha)	74	113	6
	Net emissions (kt CO ₂)	65.6	104.7	-4.1
Total net emissions (kt CO₂)		18.4	12.1	-145.7

Notes: 1. Change in net emissions across years includes ongoing forest growth. This is why emissions reduced for *Newly established* forests, even though no area was added to these forests over 2021 to 2023.

2. Areas of *Newly established* and *Harvested and converted* forests do not match for individual years because conversion activities associated with each application are spread over several years.

Table A9.3.6: Breakdown of carbon equivalent forests (CEFs) by domestic scheme application from 2021 to 2023

Scheme ID	Management type	2021	2022	2023
CEF - 2	Net emissions (kt CO ₂)	-4.3	-6.7	-9.2
CEF - 3	Net emissions (kt CO ₂)	-7.2	-11.8	-15.3
CEF - 4	Net emissions (kt CO ₂)	-0.4	-0.4	-0.5
CEF - 8	Net emissions (kt CO ₂)	-1.6	-2.2	-2.4
CEF - 9	Net emissions (kt CO ₂)	-0.7	-1.1	-1.1
CEF - 11	Harvested and converted (ha)	55	113	6
	Net emissions (kt CO ₂)	36.7	77.3	-52.9

Scheme ID	Management type	2021	2022	2023
CEF - 12	Net emissions (kt CO ₂)	-4.8	-6.8	-7.3
CEF - 13	Net emissions (kt CO ₂)	-3.1	-4.5	-4.8
CEF - 14	Net emissions (kt CO ₂)	-2.5	-4.4	-6.3
CEF - 15	Net emissions (kt CO ₂)	-3.3	-5.6	-8.0
CEF - 17	Net emissions (kt CO ₂)	-0.1	-0.2	-0.3
CEF - 18	Net emissions (kt CO ₂)	-1.0	-2.1	-3.7
CEF - 19	Net emissions (kt CO ₂)	-0.8	-1.9	-3.3
CEF - 20	Net emissions (kt CO ₂)	-0.2	-0.4	-0.6
CEF - 21	Net emissions (kt CO ₂)	-2.9	-5.1	-7.3
CEF - 24	Net emissions (kt CO ₂)	-0.4	-0.6	-0.9
CEF - 25	Harvested and converted (ha)	19	-	-
	Net emissions (kt CO ₂)	17.7	-4.6	-8.0
CEF - 27	Net emissions (kt CO ₂)	-0.8	-1.4	-2.1
CEF - 31	Net emissions (kt CO ₂)	-0.1	-0.2	-0.3
CEF - 35	Net emissions (kt CO ₂)	-0.0	-0.1	-0.2
CEF - 36	Net emissions (kt CO ₂)	-0.6	-1.6	-3.7
CEF - 38	Net emissions (kt CO ₂)	-0.0	-0.1	-0.2
CEF - 39	Net emissions (kt CO ₂)	-0.4	-1.0	-2.2
CEF - 40	Net emissions (kt CO ₂)	-0.1	-0.3	-0.6
CEF - 41	Net emissions (kt CO ₂)	-0.0	-0.1	-0.1
CEF - 42	Net emissions (kt CO ₂)	-0.3	-0.7	-1.4
CEF - 43	Net emissions (kt CO ₂)	-0.2	-0.4	-0.8
CEF - 44	Net emissions (kt CO ₂)	-0.1	-0.2	-0.3
CEF - 45	Net emissions (kt CO ₂)	-0.0	-0.1	-0.3
CEF - 47	Net emissions (kt CO ₂)	-0.0	-0.2	-0.5
CEF - 49	Net emissions (kt CO ₂)	-0.1	-0.3	-0.7
CEF - 51	Net emissions (kt CO ₂)	-0.0	-0.1	-0.3
Total	Harvested and converted (ha)	74	113	6
	Total net emissions (kt CO ₂)	18.4	12.1	-145.7

Note: Values of 0.0 represent absolute values smaller than 0.05.

A carbon equivalent forest provision is included and administered domestically by the New Zealand Ministry for Primary Industries as part of the NZ ETS settings. The domestic carbon equivalent forest rules are broadly aligned with those in the 2013 Kyoto Protocol Supplement (IPCC, 2014). Misalignments between the international rule set and the domestic scheme include:

- the carbon equivalent forest can be established before the forest land is converted to another land use
- the newly established carbon equivalent forest can be established on land that was forested on 31 December 1989.

Where these misalignments are observed, these activities are instead reported and accounted for as separate afforestation and deforestation events and excluded from the carbon equivalent forest accounting provision that is applied to *Forest management* activities.

Emissions from the conversion of forest land under the carbon equivalent forest accounting provision are calculated as a deforestation event. Net emissions are calculated as outlined in section A9.3.3. The emissions from the establishment of the new forest under the provision

are calculated as an afforestation event as outlined in section A9.3.2. Net emissions from these activities are reported under *Forest management* and monitored over time, to ensure carbon equivalence is achieved within the normal harvesting cycle of the harvested and converted forest plantation.

The carbon equivalent forest accounting provision creates a misalignment between the reporting of afforestation and deforestation areas here and in volume 1, chapter 6. This land is reported as *Land converted to forest land* (afforestation) and *Forest land converted to other land uses* (deforestation) in the LULUCF sector of the Inventory. Further misalignment occurs due to the Inventory transition of areas of *Afforestation and reforestation land* (*Land converted to forest land*) into *Forest land remaining forest land* after a period of 20 years.

Table A9.3.7 shows the correspondence between how forest land is reported in LULUCF activities and inventory categories.

Table A9.3.7: Comparison of forest areas reported under each LULUCF inventory category and LULUCF activities as at 31 December 2023 (kha)

LULUCF activity	Inventory land category		Total
	Forest land remaining forest land	Land converted to forest land	
Afforestation and reforestation	543.6	446.3	990.0
Deforestation – replanting on deforested land	-	2.6	2.6
Forest management – excluding newly established CEF	9,175.4	-	9,175.4
Forest management – newly established CEF	-	4.9	4.9
Total	9,719.1	453.8	10,172.9

Note: CEF = carbon equivalent forest. Columns may not total due to rounding.

A9.3.5 Harvested wood products

New Zealand has a large, planted forest estate that provides most of the wood products consumed domestically. The remainder of domestic production is exported in either product or raw material form. A more detailed description of the forest estate and New Zealand wood use is provided in annex 5, sections A5.2.5 and A5.2.6.

The HWP pool comprises all wood material that leaves a harvest site and is subsequently processed. This pool constitutes a carbon reservoir (section 12.1, IPCC, 2006b).

New Zealand accounts for the changes in the HWP pool using the production approach. For *Afforestation and reforestation* and *Forest management*, estimates are derived from a modified IPCC (2006b) reporting model.

The emissions from HWP originating from *Deforestation* activities have been instantly oxidised since 2008 when New Zealand began accounting for its emissions.

Net emissions from HWP derived from *Afforestation and reforestation* activities in 2023 were -5,180.8 kt CO₂-e. Net emissions from HWP derived from *Forest management* activities in 2023 were -4,167.2 kt CO₂-e.

New Zealand's accounting approach to *Afforestation and reforestation* activities includes the HWP pool in the LTA calculation (Dovey and Wakelin, unpublished). New Zealand's accounting approach to *Forest management* activities includes the HWP pool in the pre-1990 FRL calculation.

New Zealand has developed a Tier 2 method to report on net emissions from the HWP pool. New Zealand uses the default Tier 2 methodology, as described in the 2013 Kyoto Protocol Supplement (IPCC, 2014), and some country-specific activity data and parameters where available. Country-specific half-life values are applied to sawnwood and wood-based panels produced from domestic roundwood for domestic and export markets (Wakelin, unpublished(a); Wekesa, 2022; Wekesa et al, 2022). IPCC default half-life values are used for paper and paperboard. More information on the sub-product half-life values and their proportions for the domestic and export market is provided in annex 5, section A5.2.6 and tables A5.2.23, A5.2.24 to A5.2.27. Country-specific conversion factors are used for domestically produced sawnwood and veneer sheets (see volume 1, chapter 6, section 6.10).

Activity data on roundwood production volume and roundwood export volume are sourced from the Ministry of Primary Industries (Ministry for Primary Industries, 2024c). These activity data are disaggregated into subcategories with different carbon fractions in the HWP model, using data from the Statistics Division of the United Nations Food and Agriculture Organization statistical database (FAOSTAT).

Activity data used for compiling LULUCF sector accounting estimates for HWP are the same as that used for the Inventory, except the time series begins in 1990 for *Afforestation and reforestation* and 2013 for *Forest management* whereas the Inventory time series for all forests starts at 1900. Also, the *Solid wood* category used for LULUCF sector reporting is disaggregated into *Sawnwood* and *Wood-based panels* for LULUCF sector accounting.

Emissions from HWP derived from *Afforestation and reforestation* activities are reported from 1990 onwards, including from harvest. Harvest activities provide a growing contribution to the HWP pool as the forests reach harvest age. HWP originating from *Afforestation and reforestation* activities each year are estimated by prorating the above-ground biomass carbon losses from the harvest of these lands to the total above-ground biomass carbon losses from all harvesting and deforestation activities.

Harvesting is the primary driver of emissions from *Forest management* activities. Emissions from HWP derived from *Forest management* activities each year are estimated as they are for *Afforestation and reforestation* activities, by prorating the above-ground biomass carbon losses from the harvest of these lands to the total above-ground biomass carbon losses from all harvesting and deforestation activities. Accounting for HWP from *Forest management* activities is against New Zealand's projected pre-1990 FRL.

While the HWP originating from *Deforestation* activities are accounted for as an instant emission, the production statistics do not identify products that were derived originally from the wood that was harvested as part of the deforestation activity. The share of roundwood volume originating from *Deforestation* is estimated by comparing the above-ground biomass carbon losses from *Deforestation* with the above-ground biomass carbon losses from harvesting. This provides a proportion to apply to the production statistics to separate HWP originating from *Deforestation*.

Non-forest harvest is treated as an instant emission. Harvest from these lands is assumed to be used for fuel wood. Therefore, the HWP contribution from non-forest lands is assumed to be zero.

A9.3.6 Other greenhouse gas sources

Direct nitrous oxide emissions from nitrogen fertilisation

New Zealand's activity data on nitrogen fertilisation are not currently disaggregated by land use; therefore, all nitrous oxide (N₂O) emissions from nitrogen fertilisation are reported under the Agriculture sector in the category *Direct N₂O emissions from managed soils* and are therefore fully accounted for.

Methane and nitrous oxide emissions from drained and rewetted organic soils

New Zealand reports on N₂O emissions, as a result of oxidation of organic matter, from the drainage of organic soils subject to *Afforestation and reforestation*, *Deforestation* and *Forest management* activities. Emissions are estimated following the methodology outlined in the 2006 IPCC Guidelines (IPCC, 2006b) and described in volume 1, chapter 6, section 6.11.2. Total annual emissions for these three activities in 2023 are 0.4 kt N₂O. The emissions occurring under each activity are reported in table A9.3.8.

Methane emissions from drained organic soils are assumed to be negligible, in accordance with the 2006 IPCC Guidelines (IPCC, 2006b).

Table A9.3.8: Nitrous oxide emissions from the drainage of organic soils by activity for 2021 to 2023

Year	Activity	Emissions (kt N ₂ O)	Emissions (kt CO ₂ -e)
2021	Afforestation and reforestation	0.2	44.5
	Deforestation	0.0	2.2
	Forest management	0.2	53.2
	Total emissions from drainage/rewetting of organic soils	0.4	100.0
2022	Afforestation and reforestation	0.2	44.8
	Deforestation	0.0	2.2
	Forest management	0.2	53.2
	Total emissions from drainage/rewetting of organic soils	0.4	100.3
2023	Afforestation and reforestation	0.2	45.1
	Deforestation	0.0	2.2
	Forest management	0.2	53.2
	Total emissions from drainage/rewetting of organic soils	0.4	100.5

Note: Columns and conversions between units may not total due to rounding.

Nitrous oxide emissions from nitrogen mineralisation and immobilisation associated with land use conversions and management in mineral soils

Nitrous oxide emissions, resulting from nitrogen mineralisation and immobilisation associated with land conversion, occur on land subject to *Afforestation and reforestation*, *Deforestation* and *Forest management* activities. The emissions are calculated following the 2006 IPCC Guidelines (IPCC, 2006b). Total annual emissions from these three activities in 2023 are 0.3 kt N₂O. The emissions occurring under each activity are reported in table A9.3.9.

Table A9.3.9: Nitrous oxide emissions from nitrogen mineralisation and immobilisation in soils by activity, for 2021 to 2023

Year	Activity	Emissions (kt N ₂ O)	Emissions (kt CO ₂ -e)
2021	Afforestation and reforestation	0.2	55.1
	Deforestation	0.0	1.7
	Forest management	0.0	0.9
	Total emissions from nitrogen mineralisation/immobilisation	0.2	57.7
2022	Afforestation and reforestation	0.3	67.0
	Deforestation	0.0	1.7
	Forest management	0.0	0.9
	Total emissions from nitrogen mineralisation/immobilisation	0.3	69.6
2023	Afforestation and reforestation	0.3	78.7
	Deforestation	0.0	1.7
	Forest management	0.0	0.9
	Total emissions from nitrogen mineralisation/immobilisation	0.3	81.3

Note: Columns and conversions between units may not total due to rounding.

Emissions associated with *Indirect N₂O emissions from managed soils* are reported under the Agriculture sector.

Biomass burning

Non-CO₂ emissions are estimated for each activity by apportioning wildfire activity data to the forest type burned, as described in annex 5, section A5.2.7. The emissions occurring under each activity are reported in table A9.3.10.

Table A9.3.10: Non-carbon dioxide emissions from biomass burning for 2021 to 2023

Year	Activity	Source emissions (kt)		Emissions (kt CO ₂ -e)		
		N ₂ O	CH ₄	N ₂ O	CH ₄	Total CO ₂ -e
2021	Afforestation and reforestation	0.0	0.2	3.2	4.5	7.7
	Deforestation	0.0	0.5	6.8	13.3	20.1
	Forest management	0.0	0.4	2.6	11.5	14.1
	Total emissions from biomass burning	0.0	1.0	12.6	29.4	41.9
2022	Afforestation and reforestation	0.0	0.2	4.1	5.4	9.5
	Deforestation	0.0	0.4	5.7	11.2	16.9
	Forest management	0.0	0.4	2.4	10.7	13.1
	Total emissions from biomass burning	0.0	1.0	12.2	27.2	39.4
2023	Afforestation and reforestation	0.0	0.3	5.1	7.3	12.4
	Deforestation	0.0	0.3	4.3	8.4	12.8
	Forest management	0.0	0.7	2.8	19.9	22.7
	Total emissions from biomass burning	0.0	1.3	12.2	35.7	47.9

Note: Columns may not total due to rounding.

Afforestation and reforestation

An age-based carbon yield table is used to estimate non-CO₂ emissions from *Afforestation and reforestation* activities. This approach assumes that the carbon stock affected by wildfire is equivalent to the carbon stock at the average stand age each year throughout the time series (Wakelin, unpublished(b)). Carbon dioxide emissions resulting from wildfire events are assumed to be captured in the harvest emissions of salvage logged stands.

A survey of controlled burning activities in planted forests was carried out in 2011. The survey indicated that, on average, 5 per cent of conversions to planted forest between 1990 and 2011 involved burning to clear vegetation. This area is allocated to *Forest management* (land converted from pre-1990 natural forest) and *Afforestation* (land converted from *Grassland with woody biomass*) on a pro-rata basis (Wakelin, unpublished(c)).

All non-CO₂ emissions associated with biomass burning from *Afforestation and reforestation* activities are fully accounted for. These emissions are not included in the calculation of the LTA age (Dovey and Wakelin, unpublished).

Deforestation

An estimate is provided for controlled burning of post-harvest residues associated with *Deforestation* activities. It is assumed that 30 per cent of the area subject to deforestation involves burning as part of land use conversion. This percentage is chosen as a conservative proportion of one of the four main methods for disposing of post-harvest residues in New Zealand. The other methods for post-harvest residue disposal are chipping and removal, mulching into the soil and leaving to decay (Goulding, unpublished).

To estimate emissions from the burning of post-harvest residue, the IPCC default combustion proportion for non-eucalypt temperate forest (0.62) (table 2.6, IPCC, 2006b) is applied to an emission factor derived from the national plot network. The emission factor excludes the proportion of logs taken offsite (70 per cent of above-ground biomass) and is taken from the relevant yield tables at the average age of harvest in New Zealand.

Estimates for non-CO₂ emissions from wildfire occurring on deforested land are based on the Inventory calculation for non-CO₂ emissions from wildfire occurring on *Forest land converted to grassland*. The activity data do not identify deforested land; therefore, non-CO₂ emissions resulting from wildfire are attributed to deforested land by the proportion of area that deforested land makes up of the total *Grassland* area. The methodology follows that described in annex 5, section A5.2.7.

Forest management

Estimates are provided for non-CO₂ emissions from wildfires occurring on land subject to *Forest management* activities. A plot-network-derived biomass density is used. Aggregated wildfire activity data have been attributed to each forest management category by proportion of forest type estimated to be burned over the time series.

A survey of controlled burning in planted forest was carried out in 2011 (Wakelin, unpublished(c)). Estimates were provided for burning associated with the clearing of vegetation (i.e., natural forest and shrubland before the establishment of exotic planted forest (see 'Afforestation and reforestation' above)).

The survey also provided data on the burning of post-harvest residues 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 the restocked area was burned annually in recent years (Wakelin, unpublished(c)). 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 (Wakelin, unpublished(c)). From 1997, the area burned declines linearly to 0.8 per cent, which is used from 2005 onwards (Wakelin, unpublished(c)).

A more detailed description of *Biomass burning on Forest land* is provided in volume 1, chapter 6, section 6.11.8 and annex 5, section A5.2.7.

A9.3.7 Natural disturbance

New Zealand applied the default method described in section 2.3.9.6 of the 2013 Kyoto Protocol Supplement (IPCC, 2014) for calculating its background level of natural disturbances for both *Afforestation and reforestation* and *Forest management* activities.

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

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

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

It is assumed that salvage logging takes place in planted forests subject to *Afforestation and reforestation* and *Forest management* activities that are also subject to natural disturbances.

The LUCAS forest plot measurement programme captures emissions from natural disturbances occurring in pre-1990 natural forests implicitly, and the emissions from natural disturbance events, apart from wildfires, cannot be separated from other disturbance events. The background levels of small-scale natural disturbance events are included in the natural forest stock change estimates.

Only direct oxidation of biomass in wildfires is considered for the purposes of calculating a background level of natural disturbance for both *Afforestation and reforestation* and *Forest management* activities, regardless of forest type. The data used are as reported in the Inventory for the period 1990 to 2009 (see volume 1, chapter 6, section 6.11.8).

Afforestation and reforestation

Due to the nature of the carbon stock change estimation methods for *Afforestation and reforestation* activities, the background level of CO₂ emissions from natural disturbance is already captured implicitly within the reported emissions estimates.

New Zealand separately estimates and reports the non-CO₂ emissions from natural disturbances on land subject to *Afforestation and reforestation* activities.

The background level of natural disturbances has been calculated using the default method described in section 2.3.9.6 of the 2013 Kyoto Protocol Supplement (IPCC, 2014). Both the post-1989 forest area and the carbon stock increase during the calibration period. To account for the annual change, the background level for the calibration period is calculated as a proportion of the post-1989 forest estate. This proportion is then multiplied by the carbon stock in post-1989 forest for each year in the reporting period (2021 to 2030). This approach provides the background level and corrects for the increasing area and age (and therefore carbon stock exposed to natural disturbance) in post-1989 forests.

The background level of natural disturbance emissions from *Afforestation and reforestation* activities for 2020 was 2.26 kt CO₂-e.

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

The natural disturbance background level is calculated using the default methodology described in section 2.3.9.6 of the 2013 Kyoto Protocol Supplement (IPCC, 2014). The proportion from the calibration period is then multiplied by the carbon stock in post-1989 forest for each year in the reporting period (2021 to 2030). This approach is taken for the following reasons.

- A trend is observed in natural disturbance emissions during the calibration period for *Afforestation and reforestation*. Emissions from natural disturbances have been increasing throughout the calibration period as the age of these forests, and therefore biomass, increases through time. The calibration period was used to obtain an annual emissions value by proportion of carbon stocks and then used to calculate the background level for the 2021 year onwards, based on the carbon stocks of *Afforestation and reforestation* lands in each year.
- Emissions from natural disturbances occurring within *Afforestation and reforestation* activities in any year of NDC1, which fall below the background level, are not excluded from the accounting. Emissions from natural disturbances that are greater than the background level in any year of NDC1 are able to be excluded from the accounting if a Party chooses.
- If emissions from natural disturbances are greater than the background level, they can be excluded from the accounting. Further work is planned to ensure there is no expectation of net debits arising from implementation of this exclusion when applying the LTA to account for these forests.
- If emissions are less than the background level in any year of the accounting period, all emissions from natural disturbance will still be accounted for. There is no expectation of net debits in this scenario.

Forest management

The annual background level of emissions from natural disturbance for *Forest management* was calculated as 9.40 kt CO₂-e.

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

The background level has been calculated using the default methodology described in section 2.3.9.6 of the 2013 Kyoto Protocol Supplement (IPCC, 2014). By using this method, the expectation of net credits or net debits for the application of the natural disturbance provision is avoided for the following reasons.

- No observed trend is evident in natural disturbance emissions during the calibration period for *Forest management* and therefore none can be expected during NDC1.
- Emissions from natural disturbances occurring during the accounting period that fall below the background level are not excluded from the accounting. During the accounting period, emissions from natural disturbances that are above the background level are, subject to New Zealand's discretion, able to be excluded from the accounting.

- The accounting for *Forest management* is against a projected business-as-usual pre-1990 FRL. The background level is included implicitly within the pre-1990 FRL, and any emissions greater than the background level can be excluded from the accounting.

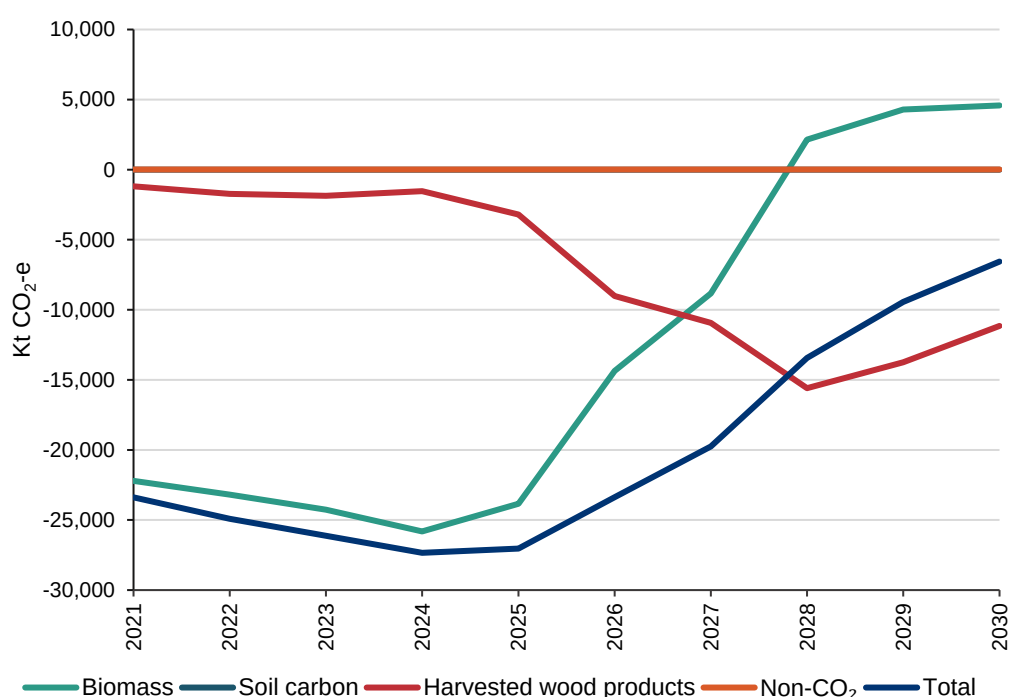
A9.4 Other methodological issues

A9.4.1 Development of the pre-1990 FRL

The pre-1990 FRL value is -20,135 kt CO₂-e per year representing the projected average annual net emissions from pre-1990 forests under business-as-usual management from 2021 to 2030. This is made up of a pre-1990 planted forest FRL value of -18,735 kt CO₂-e per year and a pre-1990 natural forest FRL of -1,399.5 kt CO₂-e per year.

Carbon uptake in pre-1990 planted forests is initially high during the compliance period because harvesting is concentrated in post-1989 planted forests, but it then declines and pre-1990 planted forests become a net source of emissions. However, this is balanced by gains in the HWP pool. Other emissions from soil carbon loss (due to land-use change) and wildfires are relatively small (figure A9.4.1).

Figure A9.4.1: Pre-1990 forest reference level for 2021 to 2030



Note: The changes in non-CO₂ are not visible, due to its small total emissions value.

The pre-1990 FRL was developed using the reference period 2000 to 2009 and following the main methodological steps described in the European Union approach to pre-1990 FRL development (Forsell et al, 2018), based on earlier work by Grassi and Pilli (2017). The steps, as adapted for New Zealand's activity-based accounting,¹² are as follows.

1. Stratify the area subject to *Forest management* activities based on national circumstances. Strata should be characterised by specific management objectives and practices.
2. Identify and stratify the forest management practices for each stratum during the reference period. These should be quantifiable criteria, for example, the age, diameter or volume at which thinning or harvesting occurs, and monitored over time to document changes.
3. Project the evolution of area subject to *Forest management* activities, assuming that the deforestation rate over the reference period continues.
4. Project the future carbon gains and losses in each pool and stratum including:
 - a) growth in each forest stratum assuming continuation of management practices that applied in the reference period
 - b) losses due to harvesting using a harvest fraction approach to harvest biomass available for wood supply through to the end of the compliance period.
5. Estimate projected HWP pool stock changes by applying the same HWP category proportions as during the reference period.

Wakelin and Paul (2024b) adapted and applied the methodological steps described above to develop the pre-1990 FRL for New Zealand's *Forest management* activities.

Pre-1990 planted forests were stratified into two cohorts corresponding to stands planted before 1990 and stands planted after 1989. This was done to allow the use of a different yield table for the younger stands of trees and, with this, account for the fact that these stands include faster growing genotypes (Wakelin and Paul, 2024b).

To project the evolution of the pre-1990 planted forest estate, a destocking probability approach, based on the destocking profile by age class that applied from 2007 to 2009,¹³ was used to generate an annual time series of harvesting and deforestation area by age from 2010 to 2030. This time series, and the corresponding yield tables for each stratum, were applied to a simulation in the LUCAS CRA, to project the corresponding carbon gains and losses for planted forests under *Forest management* from 2010 through to the end of the compliance period (Wakelin and Paul, 2024b).

The LUCAS CRA is the same application that is used to model LULUCF emissions and removals reported in the Inventory and the accounting quantities for the NDC. Additional calculations were made for soil carbon stock changes, wildfire emissions and net emissions from the HWP pool (Wakelin and Paul, 2024b). The resulting emissions were added to those generated by the LUCAS CRA simulation to form the pre-1990 planted forest FRL.

¹² Note that the European Union method applies a 'land-based' rather than 'activity-based' approach, in line with greenhouse gas inventory reporting, so the pre-1990 (*Forest management*) and post-1989 (*Afforestation and reforestation*) distinction made under the Kyoto Protocol is not used. New Zealand applies an activity-based approach and, therefore, stratifies this area as that subject to *Forest management* activities (i.e., pre-1990 forest area) rather than the area reported under *Forest land remaining forest land* in the Greenhouse Gas Inventory.

¹³ The years 2007 to 2009 were selected because a trend was detected within the 2000 to 2009 reference period (Wakelin and Paul, 2024b).

Pre-1990 natural forests were stratified into tall and regenerating forests, recognising that each of these strata has a different mean rate of sequestration (Wakelin and Paul, 2024b). Harvesting is not anticipated in either case, so these strata were differentiated by the mean sequestration rate derived from the LUCAS forest plot network (Wakelin and Paul, 2024b). These rates were applied to a projection of the 2009 natural forest area¹⁴ that took into account actual deforestation from 2010 to 2020 and projected deforestation from 2021 to 2030 to generate the carbon gains and losses from changes to the forest biomass. Additional calculations were made for soil carbon stock changes and wildfire emissions, and integrated with the projected carbon gains and losses from the forest biomass to generate the natural forest FRL (Wakelin and Paul, 2024b).

Further work is planned to implement technical corrections to the pre-1990 FRL that incorporate actual deforestation and changes to the area of forests accounted for under *Forest management*.

A9.4.2 Uncertainty and time-series consistency

The uncertainty in net emissions from *Afforestation and reforestation* in 2023 is ± 21.5 per cent at the 95 per cent confidence interval. This is based on the uncertainty in emissions from post-1989 planted forests, post-1989 natural forests and their corresponding HWP (table A9.4.1 and table A9.4.2).

The uncertainty in net emissions from *Deforestation* is determined by the forest type (table A9.4.1). The combined uncertainty introduced into emissions from *Deforestation*, at the 95 per cent confidence interval for 2023, was ± 1.3 per cent (table A9.4.2).

The combined uncertainties in net emissions from *Forest management* in 2023 are ± 41.6 per cent at a 95 per cent confidence interval (table A9.4.2). This is the combined uncertainty of pre-1990 natural forest and pre-1990 planted forest and includes uncertainty associated with HWP.

Further detail on the uncertainty in net emissions for pre-1990 natural forest, pre-1990 planted forest, post-1989 planted forest, post-1989 natural forest and HWP is provided in volume 1, chapter 6, section 6.4.3 and section 6.10.3.

Total uncertainties in New Zealand's estimates of emissions for *Afforestation and reforestation*, *Deforestation* and *Forest management* activities in 2023 were ± 46.9 per cent at a 95 per cent confidence interval (table A9.4.2).

Uncertainty also arises from the determination of the LTA carbon stock and LTA age for production planted forests in *Afforestation and reforestation*. The estimated LTA carbon stock reflects current forest management based on the best information available (Dovey and Wakelin, unpublished). Inputs include growth rates (represented by yield tables derived from the LUCAS forest plot network), rotation age, species split in the planted forest estate, and the lifespan of wood products (section A9.3.2). A simulation to determine the LTA estimate was run over eight planting and harvesting rotations. The LTA was reasonably insensitive to changes in inputs, especially given the expected average rotation lengths, relative to any delayed emissions from HWP or harvest residues (Dovey and Wakelin, unpublished). It is not clear the extent to which uncertainty in LTA carbon stock or LTA age estimates will affect overall uncertainty in emissions estimates, and further work to quantify this is planned.

¹⁴ As reported in the *New Zealand Greenhouse Gas Inventory 1990–2022* (Ministry for the Environment, 2024b).

Table A9.4.1: Uncertainty in New Zealand's estimates for *Afforestation and reforestation*, *Deforestation* and *Forest management* activities in 2023

	Uncertainty (%) at a 95% confidence interval							
	Afforestation and reforestation		Deforestation			Forest management		
	Post-1989 planted forest	Post-1989 natural forest	Pre-1990 natural forest	Pre-1990 planted forest	Post-1989 planted forest	Post-1989 natural forest	Pre-1990 natural forest	Pre-1990 planted forest
Activity data								
Land area	±8.0	±8.0	±5.0	±5.0	±5.0	±5.0	±5.0	±5.0
Emission factors								
Biomass carbon stocks (losses)	±20.5	-	±27.2	±20.5	±20.5	±27.0	-	±20.5
Biomass carbon change (gains)	±10.4	±44.8	-	-	-	-	±119.6	±11.8
Soil carbon stocks	±10.4	±10.4	±7.9	±12.3	±10.4	±10.4	±7.9	±12.3
Harvested wood products	±68.2	-	-	-	-	-	-	±68.2
Total uncertainty by activity and forest type								
2023	±21.5	±0.9	±0.2	±0.4	±1.3	±0.0	±13.5	±39.4

Note: All land that has been afforested or reforested since 1 January 1990 is defined as post-1989 forest, unless occurring on land deforested since 1 January 1990. Land deforested since 1 January 1990 includes land that was pre-1990 natural forest, pre-1990 planted forest, post-1989 planted forest or post-1989 natural forest.

Table A9.4.2: Total uncertainty in New Zealand's estimates for *Afforestation and reforestation*, *Deforestation* and *Forest management* in 2023

Activity	Uncertainty in emissions (%) at a 95% confidence interval
Afforestation and reforestation uncertainty	21.5
Deforestation uncertainty	1.3
Forest management uncertainty	41.6
Total	46.9

A9.4.3 Quality control and quality assurance

Quality-control and quality-assurance procedures have been adopted for all data collection and data analyses, to be consistent with the IPCC General Guidance and Reporting (IPCC, 2006a) and New Zealand's LULUCF inventory quality-control and quality-assurance plan. Quality-control and quality-assurance plans were established for each type of data used to determine carbon stock and stock changes, as well as the areal extent and spatial location of land-use changes. All data were subject to an independent and documented quality-assurance process. Data validation rules and reports were established to ensure all data are fit for purpose and of a consistent and known quality, and that data quality continues to be improved over time. The data used to derive the country-specific yield tables and average carbon values have also undergone quality assurance, as described in annex 5, section A5.2.5.

A9.4.4 Recalculations

New Zealand's greenhouse gas estimates for activities accounted for in NDC1 have been recalculated since they were first reported in New Zealand's first Biennial Transparency Report (Ministry for the Environment, 2024a), to incorporate improved activity data.

These updates resulted in small total net emissions recalculations of less than 1 per cent in both 2021 and 2022, and across the 2021 to 2022 period combined (table A9.4.3). The largest absolute differences in net emissions between the 2024 and 2025 submissions occurred for *Afforestation and reforestation* where net emissions reduced by 358 kt CO₂-e across the 2021 to 2022 period.

Table A9.4.3: Recalculations of New Zealand's total net emissions (kt CO₂-e) by activity from 2021 to 2022

Year	Activity	2024 submission	2025 submission	Change from 2024 submission (%)
2021	Afforestation and reforestation	-10,824.4	-11,012.8	-1.7
	Deforestation	3,170.8	3,126.0	-1.4
	Forest management	-18,215.6	-18,145.6	0.4
	Total net emissions in calendar year	-25,869.2	-26,032.4	-0.6
2022	Afforestation and reforestation	-8,576.1	-8,745.2	-2.0
	Deforestation	2,429.4	2,347.4	-3.4
	Forest management	-18,600.0	-18,433.2	0.9
	Total net emissions in calendar year	-24,746.7	-24,831.0	-0.3
2021–2022	Afforestation and reforestation	-19,400.5	-19,758.0	-1.8
	Deforestation	5,600.2	5,473.4	-2.3
	Forest management	-36,815.5	-36,578.8	0.6
	Total net emissions in period	-50,615.9	-50,863.3	-0.5

Activity data

In this submission, the total area of deforestation in 2022 decreased (table A9.4.4) compared with the estimate made for the 2024 submission of the first Biennial Transparency Report (Ministry for the Environment, 2024a). This is a consequence of updated deforestation mapping for the period 2017 to 2020, which adjusted the estimated deforestation area for 2021 and 2022.

When compared with the 2024 submission, the estimated post-1989 forest harvest area reduced by 853 hectares, countered by an increase in pre-1990 forest harvest area of 976 hectares (table A9.4.4). This change was driven by revised mapping of post-1989 forest harvest areas for 2022. For further information on the methods used to estimate the harvest area of pre-1990 and post-1989 forests see annex 5, section A5.2.5.

Table A9.4.4: Recalculations of New Zealand's net cumulative area and activity data for 2022

Activity	2024 submission	2025 submission	Change from 2024 submission (%)	
Net cumulative area as at 2022 (ha)				
Afforestation and reforestation	909,130	908,901	-0.0	
Deforestation	241,892	240,908	-0.4	
Forest management	9,186,383	9,185,546	-0.0	
Total area included (ha)	10,337,405	10,335,355	-0.0	
Activities occurring in 2022 (ha)				
Afforestation and reforestation	Afforestation: Planted forest – production	74,710	74,702	-0.0
	Afforestation: Planted forest – permanent	4,853	4,853	-0.0
	Afforestation: Natural forest	6,874	6,829	-0.7
	Harvest: Post-1989 planted forest	21,428	20,575	-4.0
Deforestation	Pre-1990 natural forest	575	570	-0.9
	Pre-1990 planted forest	256	245	-4.2
	Post-1989 planted forest	3,141	3,018	-3.9
	Post-1989 natural forest	117	158	34.1
	Total	4,089	3,991	-2.4
Forest management	Harvest: Pre-1990 planted forest	26,811	27,787	3.6

Emissions factors

No changes to emission factors have been made since the 2024 submission of first Biennial Transparency Report (Ministry for the Environment, 2024a).

9.4.6 Update to 2020 provisional accounting quantities

Emissions and removals occurring during 2020 do not contribute LULUCF accounting for the NDC1 period, however, the accounting quantity is used to establish a 2020 baseline of total emissions for measuring progress towards international and domestic targets and budgets.

Emissions from activities occurring in 2020 have increased slightly (0.2 per cent) as a result of recalculation of the time series (table A9.4.5) since the 2024 submission of the first Biennial Transparency Report (Ministry for the Environment, 2024a). The updated provisional accounting quantities for 2020 are shown in table 9.4.6.

Table A9.4.5: New Zealand's total net emissions (kt CO₂-e) by activity in 2020

Year	Activity	2024 submission	2025 submission	Change from 2024 submission (%)
2020	Afforestation and reforestation	-12,316.0	-12,393.9	-0.6
	Deforestation	4,777.3	4,812.7	0.7
	Forest management	-18,570.9	-18,473.8	0.5
	Total net emissions in calendar year	-26,109.6	-26,055.0	0.2

Table A9.4.6: New Zealand's provisional accounting quantities for 2020

Provisional accounting quantities by activity		
Afforestation and reforestation	Below LTA accounting emissions	-10,953.9
Deforestation	Deforestation	4,812.7
Accounting quantity for 2020	Excluding <i>Forest management</i>	-6,141.2

A9.4.5 Planned improvements

The following methodological improvements are planned to support the accounting approach to the LULUCF sector.

- Technical corrections to the FRL to incorporate:
 - actual deforestation, and corresponding changes to the area of forests accounted for under *Forest management*, occurring during NDC1
 - periodic updates to carbon stock changes and yield tables based on forest plot remeasurements.
- Investigation of options for reconciling the actual emissions from *Afforestation and reforestation* activities with the emissions included in the averaging approach at the end of NDC1. This includes determining whether *Afforestation and reforestation Above LTA* emissions are consistent with expected values, and accounting for any difference, either through an FRL or an end-of-period recalculation of the LTA.
- Improvement to the approach for defining the background level for natural disturbances in the *Afforestation and reforestation* and *Forest management* categories. This includes the approach for implementing the natural disturbance provision when it is invoked for *Afforestation and reforestation* in the context of LTA accounting.
- Investigation to further characterise the area, species composition and management practices in permanent forests and determine the corresponding LTA carbon stock and age.

- Investigation of options for determining the effect of LTA uncertainty on accounting quantities for *Afforestation and reforestation*.
- Confirmation of areas of deforestation occurring in the 2021 to 2023 period, through land use mapping.

A9.5 Demonstration that activities apply

A9.5.1 Year of the onset of an activity

The 2013 Kyoto Protocol Supplement requires Parties to account for Land Use, Land-Use Change and Forestry emissions and removals from afforestation, reforestation and deforestation activities beginning with the onset of the activity or the beginning of the reporting period, whichever is later (IPCC, 2014). In practical terms, this means there is a need to differentiate activities that occurred between 1 January 1990 and 31 December 2020 from those occurring during NDC1.

The area subject to *Afforestation and reforestation* activities in each year is estimated from the LUCAS land use map and the NEFD survey (Ministry for Primary Industries, 2024b), as described in annex 5, section A5.2.1 and section A5.2.2. This information ensures the activity is attributed to the correct year of onset.

Deforestation is first detected using annual satellite imagery and confirmed using high resolution satellite imagery or aerial photography. The year of onset (destocking year) is therefore determined from the first year of detection of forest loss in the annual satellite imagery time series. Because deforestation mapping has not yet been completed for activity occurring in 2021 and 2022, the total deforestation area for these years has been estimated as described in annex 5, section A5.2.2.

It can take up to four years following the loss of forest cover to determine that replanting or revegetation has occurred. This is because sometimes the land owner does not replant trees immediately, but leaves the land fallow for a time. The process for monitoring this unclassified deforestation is described in section A9.5.2. When deforestation is finally confirmed, the deforestation is attributed to the year when forest cover was removed.

A9.5.2 Distinction between harvesting and deforestation

New Zealand has used the definition of *Deforestation* from the 2006 IPCC Guidelines: “the direct human-induced conversion of forested land to non-forested land” (IPCC, 2006b, p 4.74). Deforestation is different from harvesting, in that harvesting is part of usual forest management practice and involves the temporary loss of forest cover with no change in land use.

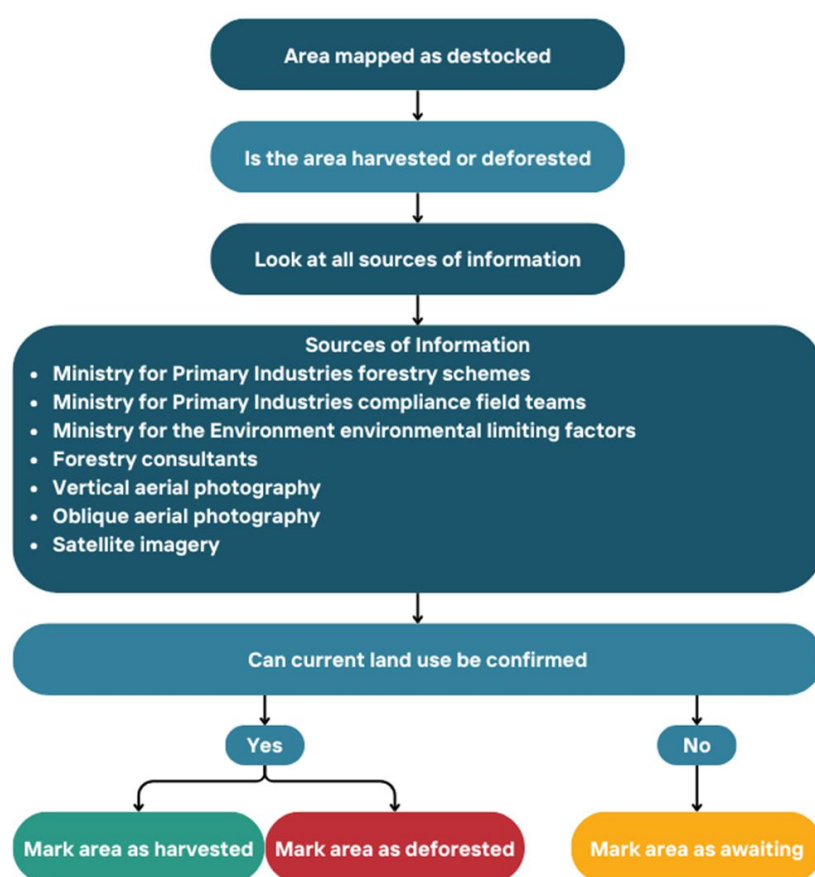
In New Zealand, temporarily unstocked or cleared areas of forest (e.g., harvested areas and areas subject to disturbances) remain designated as *Forest land* unless a change in land use is confirmed or if, after four years, there is no evidence of forestry activities occurring (i.e., either through replanting or regeneration). This follows the process for determining whether land is subject to direct human-induced deforestation as set out in section 2.6.2.1 of the 2013 Kyoto Protocol Supplement (IPCC, 2014). New Zealand has defined the expected period between the removal of tree cover and successful natural regeneration or planting as four years. In New Zealand, the tree grower and land owner are often different people. Forest land can be temporarily unstocked for several years while land owners decide what to do with land after harvesting.

Several activities are carried out to determine if land-use change has occurred, including the analysis of satellite imagery and aerial photography. The use of aerial photography is described in volume 1, chapter 6, section 6.3 and annex 5, section A5.2.2.

Evidence from the NZ ETS is also used to confirm *Deforestation*. Under the NZ ETS, owners of pre-1990 planted forest or post-1989 forest (if they are participants in the scheme) are required to notify the Government of any deforestation activity (Ministry for Primary Industries, 2024a). A data-sharing agreement is in place that allows for the Ministry for Primary Industries, the agency that administers forestry aspects of the NZ ETS, to provide the Ministry for the Environment with regular updates of the area of confirmed *Deforestation*.

A summary of the decision-making process for determining whether *Deforestation* has occurred, including all sources of information, is shown in figure A9.5.1. Once a land-use change is mapped and confirmed, the *Deforestation* emissions will be reported in the year of forest clearance.

Figure A9.5.1: Verification of deforestation in New Zealand



A9.5.3 Distinction between afforestation and shrubland

For a shrubland area to be classed as *Forest land* (and be included as an *Afforestation and reforestation* activity), as opposed to *Grassland with woody biomass*, it must meet various criteria including the forest definition criteria of having at least 30 per cent cover and being at least 1 hectare in size and 30 metres in width. It must also have the potential to reach 5 metres in height within a 30-to-40-year timeframe under current land management, and there must be evidence of intention for the land to be managed as a forest.

The potential to reach 5 metres is determined using various ancillary data including:

- location with respect to the treeline: shrub species located below but within 225 vertical metres of the treeline are not considered to have the potential to reach 5 metres in height within the required timeframe (Newsome et al, 2011)
- environmental conditions: a range of environmental conditions limit growth of shrub species in New Zealand. These include soil type, climatic conditions, geothermal activity and salt spray (Newsome et al, 2011). When a shrubland area falls within one of these zones of limitation, it is classed as *Grassland with woody biomass*
- geographical context: shrubland areas in a grazing context are unlikely to grow to 5 metres in height unless there is evidence of livestock exclusion, such as a fence line or a change to steep terrain (gully or hill), which provides a natural barrier to livestock.

The evidence that the afforestation is human induced includes data from the following.

- NZ ETS forest mapping: if an area has been accepted into the NZ ETS this is considered to be strong evidence of afforestation. The area will have been checked to verify establishment date and the potential of the area to grow to 5 metres in height. The fact the land owner has entered the area in the NZ ETS (with associated application costs) is considered strong evidence of their intention to grow a forest.
- Aerial imagery: showing fence lines, spot spraying or regular planting patterns consistent with the establishment of indigenous forest cover.

The decision tree relating to this classification of shrubland areas is described in the 'Grassland with woody biomass' section of the *Land Use and Carbon Analysis System: Satellite Imagery Interpretation Guide for Land-Use Classes* (Ministry for the Environment, 2012, p 28).

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