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Manatū Mō Te Taiao

Land Use, Land-use Change and Forestry Sector

Greenhouse Gas Emission Projections for the First Commitment Period of the Kyoto Protocol from LULUCF Activities under Article 3.3

Results, Data and Methodology

2013 Report

New Zealand Government

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Introduction

This report provides projections of carbon dioxide equivalent gas removals and emissions from New Zealand's Land Use, Land-use Change and Forestry (LULUCF) sector under Article 3.3 of the Kyoto Protocol (figure 1). The projections include post-1989 afforestation, reforestation[1] and deforestation activities, and pre-1990 planted forest and natural forest[2] deforestation.

The projections cover the first commitment period (CP1) of the Kyoto Protocol (2008–2012).

Net removals by the LULUCF sector under Article 3.3 of the Kyoto Protocol (that is, removals by post-1989 forests minus emissions from deforestation of all forest) for CP1 are projected to be between 63.3 and 90.8 million tonnes of carbon dioxide equivalent. Net removals for the central estimate are projected to be 77.2 million tonnes, 8.6 million tonnes lower than the central estimate projection in 2012 of 85.8 million tonnes (a 10.0 per cent decrease).

This decrease is due to recent information on planted forest managers' intentions for forest land that has been harvested during the first commitment period. The new information indicates higher levels of deforestation of planted forests are intended for those lands than had previously been reported.

The uncertainty in this estimate is mainly due to gaps in information about the levels of deforestation occurring. Uncertainty has been incorporated into the LULUCF projections through the use of scenarios that represent maximum and minimum emissions (termed **'upper emissions'** and **'lower emissions'**) and taking the central point of the two extremes as the '**midpoint'** estimate.

The recent 2012 Deforestation Survey (Manley, 2013), a survey of planted forest owner/manager's intentions for their forests, provides a useful indicator on their intentions to deforest. The survey was carried out in December 2012 at a time when the carbon price was between $2/NZU and $3/NZU. Some forest managers reported that at this level the deforestation liability is not a deterrent to land conversion. Several large-scale deforestation projects that had been on hold due to deforestation liabilities are again proceeding. The latest survey reported 32,000 hectares are intended to be deforested between 2008 and 2012, compared to 13,000 hectares in the 2011 survey (Manley, 2012).

This is the last year of CP1 where a net position will be published. The 2012 Greenhouse Gas Inventory (to be submitted in 2014) will replace the net position report with complete estimates for CP1. Until the 2014 estimates are available, and deforestation is confirmed by satellite imagery/aerial photography collected over the 2012/13 summer, the LULUCF projections are likely to remain the least certain of all sectors in the net position report.

Due to the change in behaviour signalled by the 2012 Deforestation Survey (Manley, 2013), projections for deforestation for CP1 are based on this new information. Areas of intended deforestation reported in this survey represent the upper estimate of deforestation which could occur during CP1 if all forest owners followed through on their intentions to deforest.

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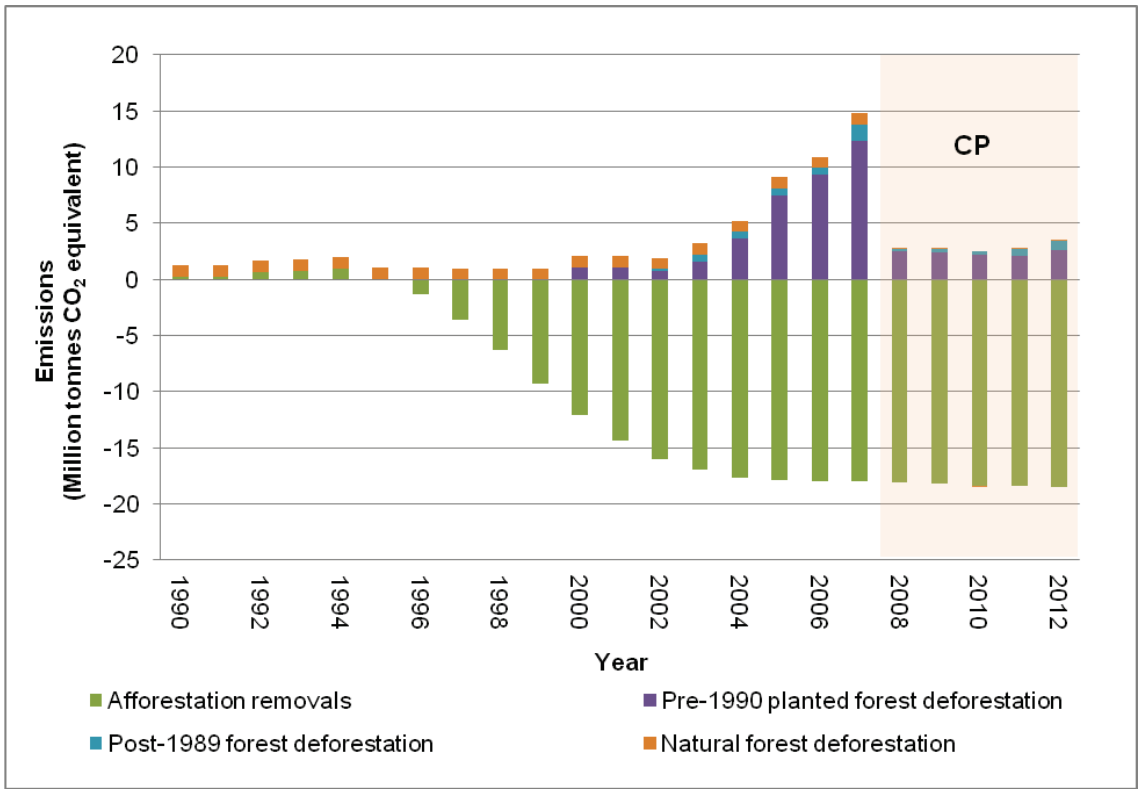
1 For the first commitment period, the definitions of afforestation and reforestation are effectively the same for New Zealand. In this document, the term afforestation is used to refer to both afforestation and reforestation ie, all new planting since 31 December 1989 on land that was previously non forest.

2 Natural forest ecosystems comprise a range of indigenous and some naturalised exotic species.

Deforestation reported in the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013) represents an estimate of all deforestation which has been completed on or before 31 December 2011. When extrapolated to include an estimate for 2012 deforestation, this represents the lower limit for deforestation which could occur during CP1.

The central estimates are based on a midpoint between these upper and lower estimates. A midpoint between these data sources has been chosen to reflect the expected area of CP1 deforestation that will be identified and confirmed by the LUCAS deforestation mapping programme for the final CPI Greenhouse Gas Inventory (to be submitted in 2014).

Figure 1: Emissions and removals from the LULUCF sector under Article 3.3 of the Kyoto Protocol (million tonnes carbon dioxide equivalent)



Notes:

The signs for removals are negative (–) and for emissions positive (+).

Emissions and removals estimates for 1990 to 2011 are based on LUCAS data. Deforestation estimates for CP1 are based on a midpoint between estimates from the Deforestation Survey (Manley, 2013) and the 2011 Greenhouse Gas Inventory (Ministry for the Environment 2013). Forecast future afforestation, and estimates of natural forest deforestation are based on historical trends.

The increase in emissions resulting from deforestation before 2008 can be largely attributed to the anticipation that government climate policies would require forest landowners to pay for deforestation emissions from the start of 2008.

Background

This report provides projections of carbon dioxide equivalent emissions and removals from New Zealand's Land Use, Land-use Change and Forestry (LULUCF) sector under Article 3.3 of the Kyoto Protocol for the period 2008 to 2012. The projections cover land subject to Article 3.3 of the Kyoto Protocol, that is, afforestation, reforestation and deforestation[3] activities occurring since 1990. For the first commitment period (CP1) New Zealand elected not to account for Article 3.4 of the Kyoto Protocol, which covers additional LULUCF activities (eg, forest management of pre-1990 planted forests and natural forests).

Three key factors are used to estimate these projections:

- mapped estimates of post-1989 forest from 1990–2007 and new planting rates sourced from the Ministry for Primary Industries' National Exotic Forest Description (NEFD) from 2008–2012
- a combination of mapped and projected areas of deforestation of post-1989 forest, pre-1990 planted forest and natural forests
- biomass and soil carbon stock changes following land-use change.

The assumptions around the likelihood of these factors provide the range of values for the **upper emissions**, **midpoint** and **lower emissions** scenarios.

Since the 2011 net position report, changes in circumstances have resulted in projections reflecting a higher deforestation rate. Data generated for the Land Use and Carbon Analysis System (LUCAS) are used for the **lower emissions** scenario. Data collection as part of the LUCAS programme will be carried out for the duration of CP1. The projections are based on the best information available as at January 2013. LUCAS data used in this report includes the area of afforestation of post-1989 forest (1990–2008) and estimates of biomass and soil carbon.

The LUCAS data for deforestation is not used for the **midpoint** estimates for this report however, unlike the previous two years. The **midpoint** estimate for deforestation for CP1 has been derived from the LUCAS data in conjunction with the most up-to-date information on deforestation intentions (Manley, 2013). Deforestation estimates reported in the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013) are based on confirmed deforestation estimates and this provides the basis for the low emissions scenario.

The 2012 Deforestation Survey (Manley, 2013) suggests a higher intention to deforest and is factored into the projections under the high emissions scenario. However, until deforestation is confirmed by satellite imagery/aerial photography undertaken over the 2012/13 summer, the total amount of deforestation that occurred over CP1 is uncertain.

A more detailed explanation of the LUCAS data used is reported in the LULUCF and Kyoto Protocol chapters of the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013).

[3] Emissions from deforestation of all forest types are included under Article 3.3 of the Kyoto Protocol.

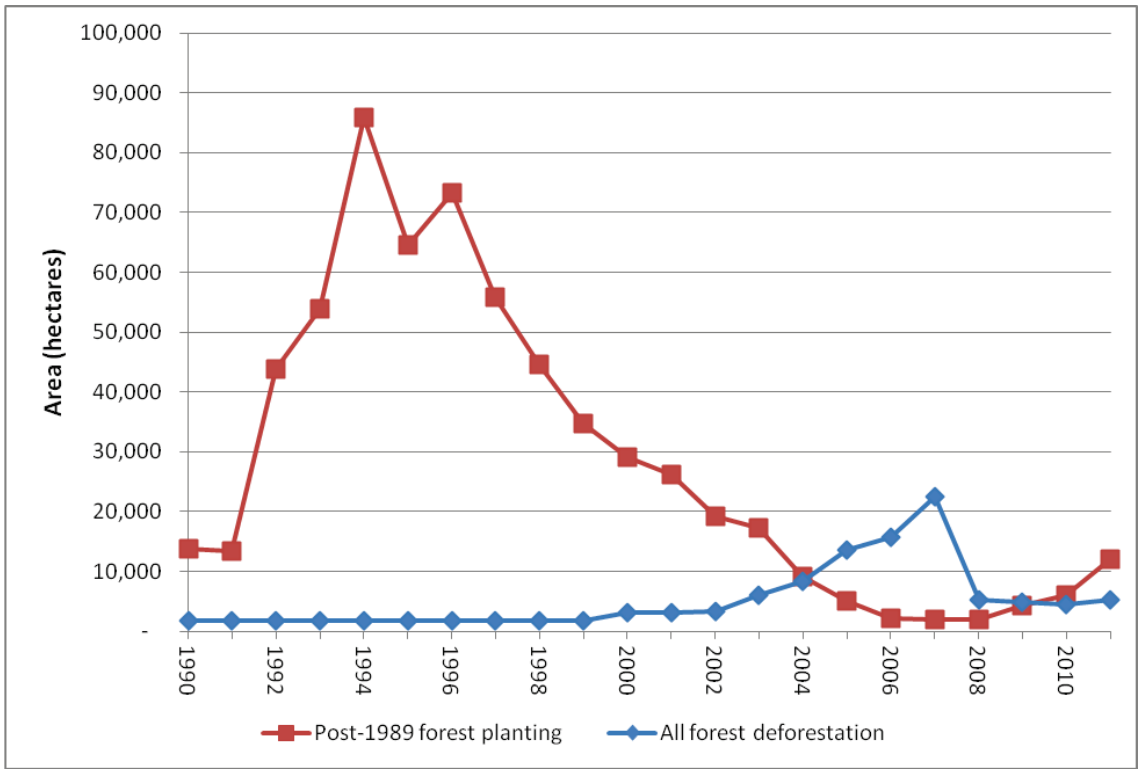
Land-use change 1990–2011

Estimates of afforestation and deforestation areas from 1990 to 2011 are based upon:

- afforestation from 1990 to 2011, estimated based on the LUCAS mapped area of post-1989 forest and the NEFD as at 1 April 2012 (Ministry for Primary Industries, 2012)
- mapped deforestation from 1990 to 2007 based on the LUCAS mapped area with information on the age profile of deforested forests from the 2008 Deforestation Survey (Manley, 2009) and unpublished work by Scion
- for 2008 to 2012, deforestation estimates are based on the LUCAS mapped data and the 2012 Deforestation Survey (Manley, 2013).

From these sources it is estimated there are approximately 598,769 hectares of post-1989 forest in 2011. The planting profile, based on forestry statistics (Ministry of Agriculture and Forestry, 2011), indicates that planting of post-1989 forest peaked at 86,000 hectares during 1994 and declined until 2008 (figure 2).

Figure 2: Estimated post-1989 forest planting and all forest deforestation for the LULUCF sector for the period 1990–2011 (hectares)



Source: Ministry for the Environment, 2013.

Since 2008, the area of post-1989 forest has been increasing. This increase is largely attributable to the Afforestation Grants Scheme. It is estimated 1900 hectares of new post-1989 forest was planted in 2008, with a further 4300 hectares planted in 2009, 6000 hectares planted in 2010, 12,000 hectares planted in 2011 and a provisional estimate of 18,500 hectares planted in 2012.

An estimated 112,164 hectares of all forest types[4] in New Zealand was deforested between 1990 and 2011, with deforestation peaking in 2007 at an estimated 23,560 hectares. The majority (71 per cent) of this deforestation is pre-1990 planted forest. Better returns from alternative land uses are the main driver for the conversion of planted forest land to other land uses.

Deforestation before 2008 was also impacted by the anticipation that government climate policies would require forest landowners to pay for deforestation emissions from the start of 2008. The deforestation rates from 2008–2012 are estimated to be between 16,741 and 35,260 hectares based on existing mapping and deforestation intentions surveys (Manley, 2011; Manley, 2012; Manley, 2013). The final mapping in 2012/13 will provide the total amount of deforestation that occurred during CP1.

Carbon density estimates

The yield tables and carbon stock values used in the 2013 projections were developed for the 2011 Greenhouse Gas Inventory[5] (Ministry for the Environment, 2013). They are described in this section.

The **post-1989 forest** carbon yield table was calculated from LUCAS field inventory data and airborne laser scanning (Light Detection and Ranging – LiDAR) measurements. This yield table was used to estimate removals of existing post-1989 forest and future afforestation, and emissions from post-1989 forest deforestation. Unless the actual age of deforestation is known, areas of post-1989 forest deforested are attributed the carbon value of the area-weighted average age of the forest estate for each year (for example, the carbon value from the yield table at the estate average age of 13 is used for 2008 deforestation).

Carbon stocks were estimated from the plot data using the Forest Carbon Predictor (version 3) (Beets and Kimberley, 2011). Regression models were developed with LiDAR metrics providing good predictions of forest carbon (tonnes of carbon per hectare) at the plot scale. The post-1989 forest yield table based on ground data alone was adjusted in a standard double-sampling routine using the LiDAR regression to increase the precision of the carbon estimate (Stephens et al, 2012).

The **pre-1990 planted forests** carbon yield table is derived from a national plot-based inventory system using the Forest Carbon Predictor (version 3) in a similar manner to the post-1989 forests. This yield table was used to estimate emissions from pre-1990 planted forest deforestation. Unless the actual age of the deforested area is known, deforestation of pre-1990 planted forest is assumed to occur at age 28, the average age of pre-1990 planted forest harvesting (Ministry of Agriculture and Forestry, 2011).

Natural forest deforestation emissions were based on the analysis of the first full round of measurements of natural forest LUCAS plots (Beets et al, 2009). The analysis of the LUCAS land-use maps and Ecosat vegetation maps have estimated that approximately 88 per cent of natural forest deforestation occurs in immature natural forest (regenerating areas that meet the forest definition) with the remaining 12 per cent being in mature natural forest.

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4 Includes all forest: post-1989 forest, pre-1990 planted forest, and natural forest.

5 For more information see http://www.mfe.govt.nz/publications/climate/new-zealand-greenhouse-gas-inventory/index.html.

Soil organic carbon stock estimates used to estimate changes in soil carbon following afforestation and deforestation were based on Tier 1 Intergovernmental Panel on Climate Change (IPCC) defaults as used in the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013). Estimation of change in soil carbon with change in land use is calculated based on the differences in equilibrium soil carbon values between the initial and final land use, with the change occurring in a linear manner over a 20-year period (IPCC default; IPCC, 2003). The change in carbon is then multiplied by the area of land-use change mapped.

Modelling process

As with the LULUCF section of the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013), the LUCAS Calculation and Reporting Application (CRA) has been used to determine projected emissions and removals for afforestation and deforestation for Article 3.3 of the Kyoto Protocol. For estimating carbon stocks and change for post-1989 forest, the CRA uses a growth simulation method as used in previous net position reports. The CRA tracks post-1989 forest areas through time and generates annual estimates of carbon stock by multiplying the area at a given age by the carbon yields per hectare for that age.

The CRA is described in more detail in the LULUCF chapter of the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013).

Policy assumptions

Emissions Trading Scheme

The New Zealand Government has implemented domestic legislation to create an Emissions Trading Scheme (NZ ETS). Some differences exist between New Zealand's obligations and entitlements under the international rules and what has been implemented in the NZ ETS. For example, under the international rules all deforestation of forest land is accounted for. Under the NZ ETS there are exclusions, such as:

1. **Forests of less than 50 hectares**. The less than 50-hectare exemption is a one-off opportunity to forest owners to exempt pre-1990 planted forest land from the NZ ETS. The exemption applies to the land, and means the land use can be changed at any time without generating liabilities under the NZ ETS.

2. **Deforestation of less than two hectares**. Up to two hectares of pre-1990 forest land can be deforested in each five-year period from 1 January 2008 under the NZ ETS, and there are no requirements to notify or surrender New Zealand Units (NZUs). Also, when pre-1990 forest is cleared and re-established within the deforestation thresholds above there are no obligations to surrender NZUs. This means business-as-usual harvesting followed by replanting is not subject to the NZ ETS. However, deforestation of more than two hectares in each five-year period from 1 January 2008 is subject to deforestation obligations under the NZ ETS.

3. **Tree weed exemptions**. Exemptions are available for the deforestation of pre-1990 forest land that is a result of legitimate tree weed forest control operations, such as the control of wilding conifers in tussock grasslands. Tree weed exemptions are available at intervals and are valid for clearance of tree weeds during specified five-year periods.
4. **Unregistered post-1989 forest land**. Post-1989 forest land which has not been registered in the NZ ETS that undergoes conversion to another land use incurs no domestic deforestation liability.

Projected emissions and removals

Sector summary

Net removals from the LULUCF sector under Article 3.3 of the Kyoto Protocol are projected to be between 63.3 and 90.8 million tonnes of carbon dioxide equivalent gas (Mt CO_2-e). This range is based on the upper and lower emission scenarios respectively. Net removals for the midpoint are projected to be 77.2 Mt CO_2-e (table 1). This is a decrease of around 8.6 Mt CO_2-e over CP1 compared with the 2012 projection of 85.8 Mt CO_2-e (10.0 per cent decrease).

Table 1 provides a breakdown of the major contributing factors on which the removals and emissions projections are based. The calculation of removals and emissions depends on several key factors and uncertainty around those factors. These are described in the following sections.

Table 1: Projected emissions and removals from the LULUCF sector under Article 3.3 of the Kyoto Protocol (million tonnes carbon dioxide equivalent) during CP1 (2008–2012)

Contributing factor		2013 projections			2012 projections
		Upper emissions scenario	Midpoint	Lower emissions scenario	Most likely scenario
Afforestation removals (Mt CO_2)	Post-1989 forest	–84.4	–91.5	–98.2	–92.2
Deforestation emissions (Mt CO_2)	Post-1989 forest	2.5	2.2	1.9	1.6
	Pre-1990 planted forest	18.2	11.7	5.2	4.6
	Natural forest	0.4	0.4	0.4	0.3
	Total deforestation	21.1	14.3	7.5	6.4
Net removals (removals less deforestation emissions) (Mt CO_2)		–63.3	–77.2	–90.8	–85.8

Notes:

Deforestation emissions include biomass emissions from the deforestation event, biomass removals of the land use after deforestation, and soil carbon change with deforestation.

Afforestation includes the biomass emissions of the land use before afforestation, soil carbon change and growth of new forest.

All forest biomass carbon is assumed to have emitted instantaneously in the year of a deforestation activity taking place. However, soil carbon changes associated with deforestation are estimated to occur over a 20-year period, the IPCC default (IPCC, 2003).

The 2013 projections assume an age of deforestation for post-1989 forest using the area weighted average age of the post-1989 forest estate in each year unless the actual age of the deforested area is known (eg, the carbon value from the yield table at the average age of 13 is used for 2008 deforestation).

The 2013 projections assume deforestation of pre-1990 forest at age 28 throughout CP1, unless the actual age of the deforested area is known.

Totals may not add due to rounding.

Post-1989 forest area

Incorporation of data from the NZ ETS and Pre-1990 Forest Land Allocation Plan has decreased the estimated gross[6] post-1989 forest area at 2007 in the 2013 projections by approximately 5096 hectares compared to the 2012 projections. The post-1989 forest area established between 1990 and 2007 is now estimated to be 593,853 hectares. A further 24,200 hectares of post-1989 forest are estimated to have been planted between 2008 and 2011 based on statistics from the Ministry for Primary Industries (MPI). The afforestation projection for 2012 for the midpoint is 18,500 hectares, resulting in a total estimated post-1989 forest planting from 1990 to 2012 of 636,553 hectares.

Based on the mapping methodology described in Dymond et al (2008), LUCAS estimated the accuracy of the post-1989 forest area from 1990 to 2007 was within ± 7 per cent. This uncertainty range is used for the upper and lower scenarios in these projections for the post-1989 forest area between 1990 and 2007. The NEFD uncertainty factor of 5 per cent was applied to the lower and upper scenarios for the 2008 to 2011 afforestation rates.

Table 2 shows the post-1989 forest planting rates used in the 2013 net position projections.

Table 2: Post-1989 forest planting since 1990 (hectares)[7]

	2013 projections			2012 projections
Period	Upper emissions	Midpoint	Lower emissions	Most likely
1990–2007	552,283	593,853	635,422	598,949
2008–2012	42,090	42,700	44,810	36,200
Total	594,373	636,553	680,232	635,149

Notes:

Table 2 only refers to existing post-1989 forest and therefore excludes the reduction in the post-1989 forest area due to deforestation.

The calendar year 2007 refers to the LUCAS land-use mapping as at 1 January 2008.

Totals may not add due to rounding.

The **upper emissions scenario** is based on:

- 7 per cent reduction in the area of post-1989 forest from 1990 to 2007 based on LUCAS mapping accuracy
- a decrease in the area of post-1989 forest of 5 per cent between 2008 and 2011 based on the confidence limits in the estimates of the NEFD
- the NEFD provisional planting estimate for post-1989 forest planting in 2012 of 18,500 hectares.

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6 The gross estimate of post-1989 forest area includes all post-1989 forest planting since 1990 and excludes the reduction in post-1989 forest area due to deforestation.

7 1990–2011 estimates for afforestation given for the midpoint are as reported in the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013). The 2011 projections used the provisional NEFD afforestation for 2009, which has been updated with the final estimate in these projections. The 2012 projections use the provisional NEFD afforestation for 2010, as in the 2010 Greenhouse Gas Inventory (Ministry for the Environment, 2012). The 2013 projections use the provisional NEFD afforestation for 2011, as in the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013).

The **midpoint** is based on:

- the area of post-1989 forest for 1990 to 2007 from LUCAS
- the area of post-1989 forest for 2008 to 2011 as reported in the NEFD
- the NEFD provisional planting estimate for post-1989 forest planting in 2012 of 18,500 hectares.

The **lower emissions scenario** is based on:

- 7 per cent increase in the area of post-1989 forest from 1990 to 2007 based on the LUCAS mapping accuracy
- an increase in the area of post-1989 forest of 5 per cent between 2008 and 2011 based on the confidence limits in the estimates from the NEFD
- higher levels of afforestation than the upper emissions scenario for 2012.

The area of post-1989 planted forest afforestation estimated for 2012 is 18,500 hectares based on the provisional NEFD afforestation estimate (Ministry for Primary Industries, 2012). This is an increase of 6500 hectares over that estimated for 2011. Gross removals from future afforestation have a limited impact in CP1, as young trees sequester only a small amount of carbon for the first few years following establishment. There is also a loss of carbon following forest establishment as the previous vegetation cover is lost before planting and as soil carbon changes during land-use transition. The impact of the removals from these newly planted forests will increase over time and have a more tangible impact in the future.

Previous land-use areas and carbon stock values before afforestation were based on the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013) with the same proportions as seen between 1990 and 2008 assumed to occur through CP1 (table 3).

Table 3: Percentage of previous land use before afforestation used through CP1 and the related carbon stock (t C ha^{-1})

Land-use subcategory	Per cent of land use before afforestation through CP1	Carbon stock used to calculate emissions
Grassland with woody biomass	29.8	29.0
Grassland – high producing	19.6	6.8
Grassland – low producing	49.8	3.1
Other land	0.7	0.0

Source: Ministry for the Environment, 2013.

Post-1989 forest carbon

Post-1989 forest growth rates for the **lower emissions, midpoint** and **upper emissions** were based on the LUCAS carbon yield table as used in the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013).

Soil carbon

Soil carbon values used in this report are based on IPCC defaults as given in good practice guidance for LULUCF. These are the values used in the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013).

Table 4 presents the equilibrium soil carbon stock estimates for each land-use subcategory. These are the soil carbon stocks under a constant land use. A change in land use generates a change in soil carbon stocks, and estimation of that change is calculated based on the differences in equilibrium soil carbon values for the respective land uses. It is assumed the change in soil carbon stocks occurs in a linear fashion over a 20-year period (this is an IPCC default; IPCC, 2003). These are the values used for the l**ower emissions, midpoint** and **upper emissions scenarios**.

Table 4: New Zealand's steady state soil carbon stock densities by land-use subcategories

Land-use class	Soil carbon stock density (t C ha^{-1})
Natural forest	92.59
Pre-90 planted forest	92.59
Post-89 planted forest	92.59
Grassland with woody biomass	92.59
High-producing grassland	117.16
Low-producing grassland	105.55
Perennial cropland	97.76
Annual cropland	59.82
Open water	0.00
Vegetated wetland	92.59
Settlements*	64.81
Other land	92.59

Source: Ministry for the Environment, 2013.

* The stock change factors for unimproved grassland with severe degradation were used in the absence of IPCC default stock change factors for settlements for this land use.

Deforestation in post-1989 and pre-1990 planted forest

New Zealand assumes instant emissions of all biomass carbon at the year the deforestation event occurs. Soil carbon changes are modelled over a 20-year time period. This assumption is based on the majority of deforestation since 1990 being forest conversion to grassland, resulting in the rapid removal of all biomass as the land is prepared for farming. As such, only soil carbon changes associated with deforestation from 1990–2007 are accounted for within CP1.

The **midpoint** projections of planted forest deforestation for 2008 to 2012 have increased compared to the estimates used in the 2012 projections (tables 5 and 6).

The **upper emission scenario** for deforestation of plantation forests in CP1 is based on a survey of forest managers which included three policy scenarios, undertaken between November and December 2012 (Manley, 2013). Under the scenario "Emissions Trading Scheme legislation continues unchanged", the 2012 Deforestation Survey indicates forest managers intended to

convert 6400 hectares of planted forest to other land uses each year during CP1. This figure is used as the basis for the upper emissions estimate. As this survey makes no distinction between pre-1990 and post-1989 forest deforestation, the proportions of each type of deforestation were derived from mapped deforestation occurring between 2008 and 2010 in the LUCAS data.

The upper emission estimate for deforestation between 1990 and 2007 is based on deforestation identified in LUCAS land-use mapping and increased by 7 per cent to account for mapping uncertainty.

The **lower emission scenario** for deforestation of plantation forests in CP1 is based on deforestation estimates from the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013). This area is generally lower than the area provided by the Manley survey as it represents only those areas where land-use change has been completed and confirmed by the LUCAS programme therefore it is unlikely to have been overestimated.

The lower emission scenario estimate for deforestation between 1990 and 2007 is based on LUCAS mapped area of deforestation between 1990 and 2007.

For the 2013 projections, the **midpoint** is based on the average of these upper and lower emission scenarios.

For the last two years, the Greenhouse Gas Inventory deforestation estimates were used for the midpoint and the Manley estimates were used for the upper emissions scenario. However, Manley (2013) reports deforestation intentions have altered significantly since early 2012 for land cleared since 2008, with deforestation intentions now considerably higher than any previous reports have indicated (c.f. Manley, 2012).

The Manley survey indicates there is likely to be additional deforestation confirmed for CP1 beyond what has been confirmed in the latest Greenhouse Gas Inventory. For this reason, using the latest Greenhouse Gas Inventory as the midpoint estimate of deforestation would likely underestimate the deforestation for CP1 that New Zealand will account for.

However, the intention to deforest is not the same as completed land-use conversion. Data from previous years has indicated confirmed deforestation levels are usually lower than the area forest managers indicate they intend to deforest. Therefore, taking the midpoint between the two extremes represents the most likely estimate of what the final confirmed deforestation area will be for CP1.

Table 5: Estimated post-1989 forest deforestation since 1990 and future deforestation (hectares)

Calendar year	2013 Projections			2012 Projections
	Upper emissions	Midpoint	Lower emissions	Most likely
1990–2007	15,391	14,384	14,384	14,384
2008–2012	7800	6850	5899	5443
Total	23,191	21,234	20,284	19,827

Notes:

The calendar year 2007 refers to the LUCAS land-use mapping as at 1 January 2008.

1990–2007 estimates for the midpoint are based on LUCAS land-use mapping, as reported in the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013).

2008–2011 estimates for the midpoint are based on the average between estimates reported in the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013) and the 2012 Deforestation Survey (Manley, 2013).

All forest biomass carbon is emitted instantaneously in the year of a deforestation activity taking place. As such, only soil carbon changes associated with deforestation from 1990–2007 are accounted for within CP1.

Totals may not add due to rounding.

Table 6: Estimated pre-1990 forest deforestation since 1990 and future deforestation (hectares)

Calendar year	2013 Projections			2012 Projections
	Upper emissions	Midpoint	Lower emissions	Most likely
1990–2007	50,938	47,605	47,605	50,635
2008–2012	24,200	15,998	7,797	7,234
Total	75,138	63,604	55,402	57,869

Notes:

The calendar year 2007 refers to the LUCAS land-use mapping as at 1 January 2008.

1990–2007 estimates for the midpoint are based on LUCAS land-use mapping, as reported in the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013).

2008–2011 estimates for the midpoint are based on the average between estimates reported in the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013) and the 2012 Deforestation Survey (Manley, 2013).

2012 estimate for the midpoint is based on the average of the upper and lower emissions scenarios.

All forest biomass carbon is emitted instantaneously in the year of a deforestation activity taking place. As such only soil carbon changes associated with deforestation from 1990–2007 are accounted for within CP1.

Totals may not add due to rounding.

Changes in biomass carbon in the land use after deforestation have been included as part of the deforestation emissions. The land use after deforestation was based on LUCAS data, with the same proportions as seen between 2008 and 2010 assumed to occur through the remainder of the commitment period (tables 7 and 8).

Table 7: Percentage of land use after post-1989 forest deforestation through CP1 and carbon stock (t C ha^{-1})

Land-use subcategory	Per cent of land use after post-1989 forest deforestation through CP1	Biomass carbon stock used to calculate emissions (t C ha^{-1})
Grassland – high producing	10	6.8
Grassland – low producing	89	3.1
Other land	1	0

Source: Ministry for the Environment, 2012.

Table 8: Percentage of land use after pre-1990 planted forest deforestation through CP1 and carbon stock (t C ha^{-1})

Land-use subcategory	Per cent of land use after pre-1990 planted forest deforestation through CP1	Biomass carbon stock used to calculate emissions (t C ha^{-1})
Grassland – high producing	14	6.8
Grassland – low producing	86	3.1
Other land	0.2	0

Source: Ministry for the Environment, 2012.

Note: Totals may not add due to rounding.

Deforestation in natural forests

Estimates of natural forest deforestation are based upon updated LUCAS mapping for 1990 to 2010. These estimates are slightly higher overall than the LUCAS estimates used in the 2012 projections, and have therefore increased the projected area of natural forest deforestation through CP1 (table 9).

The LUCAS deforestation mapping estimates 919 hectares of natural forest were deforested during 2008, 487 hectares during 2009 and 240 hectares during 2010. The estimate for 2011, of 700 hectares, is based on previous mapped trends but also includes expected deforestation from MPI data on tree weed exemption applications (Peter Lough, pers comm.). The **midpoint** for 2012 assumes the same deforestation as that estimated for 2011, resulting in 3045 hectares of total natural forest deforestation in CP1.

The **upper** emissions scenario is calculated using an adjustment to the area deforested based on the mapping uncertainty (±7 per cent).

The **lower** emissions scenario is calculated using an adjustment to the area deforested based on the mapping uncertainty (±7 per cent) for 1990 to 2007, actual areas of deforestation for 2008 to 2010, and the same estimated area of deforestation in 2011 occurring in 2012. Again the actual areas of deforestation are used for the lower emissions scenario as these are confirmed areas of deforestation.

Table 9: Estimated natural forest deforestation since 1990 and future deforestation (hectares)

Calendar year	2013 Projections			2012 Projections
	Upper emissions	Most likely	Lower emissions	Most likely
1990–2007	32,614	30,481	28,347	32,545
2008–2012	3260	3045	3045	2756
Total	35,875	33,526	31,392	35,300

Notes:

The calendar year 2007 refers to the LUCAS land-use mapping as at 1 January 2008.

1990 to 2011 estimates for the midpoint in the 2013 projections are based on LUCAS land-use mapping as reported in the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013).

All forest biomass carbon is emitted instantaneously in the year of a deforestation activity taking place. As such, only soil carbon changes associated with deforestation from 1990–2007 are accounted for within CP1.

Totals may not add due to rounding.

Along with the area of deforestation, the **midpoint** uses the average carbon density for natural forest (179 t C ha^{-1}). This is calculated based on a weighted average carbon stock based on the relative proportions of regenerating natural forest (57.3 t C ha^{-1}) and mature natural forest (217.9 t C ha^{-1}) as used in the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013).

As New Zealand assumes all forest biomass carbon is emitted instantaneously in the year of a deforestation event taking place, only soil carbon changes associated with deforestation from 1990 to 2007 are accounted for within CP1. Given this, there is no effect on CP1 emissions from adjusting the biomass carbon density for natural forest from 1990 to 2007 for the **lower** and **upper emission** scenarios.

Change in biomass and soil carbon from the land use following deforestation have been included as part of the deforestation emissions. The future land-use areas after deforestation are based on LUCAS data for 1990 to 2010 with the same proportion as observed through the first half of the commitment period continued for 2011 and 2012 (table 10). The carbon stocks used to calculate emissions from land use after deforestation were based on values used in the 2011 Greenhouse Gas Inventory (Ministry for the Environment, 2013).

Table 10: Percentage of land use after natural forest deforestation through CP1 and carbon stock (t C ha^{-1})

Land-use subcategory	Percent of land use after natural forest deforestation 2008–2012	Biomass carbon stock used to calculate emissions (t C ha^{-1})
Grassland – high producing	14	6.8
Grassland – low producing	82	3.1
Settlement	< 0.1	0
Other land	4	0

Source: Ministry for the Environment, 2012.

Changes to projections since 2012

Net removals from Article 3.3 of the Kyoto Protocol for LULUCF are projected to be 8.6 million tonnes carbon dioxide equivalent lower than projected in the 2012 LULUCF net position report. The main change from the 2012 report is a likely increase in deforestation during CP1.

Deforestation emissions are projected to be 7.90 million tonnes higher than estimated in 2012. The change in forest owner behaviour signalled by the latest deforestation intentions survey indicates a higher rate of deforestation intention than previously shown and has resulted in a rise in the emissions from deforestation of 7.16 million tonnes in pre-1990 forests, of 0.63 million tonnes in post-1989 forests and 0.11 million tonnes in natural forest. The total area of deforestation during CP1 used in the 2012 report for the midpoint was 15,435 hectares, compared to 25,893 hectares used in this report.

Future improvements to accounting under Article 3.3 during CP1

New Zealand's estimates and projections have been progressively improving in accuracy and completeness during CP1 as a result of additional data collection for forest land and planned improvements under the LUCAS programme as outlined below:

- At the end of the first commitment period New Zealand will produce a 2012 land-use map using high-resolution satellite data. This mapping will be used to make comparisons with the 2007 land-use map to identify land-use changes between 1 January 2008 and 31 December 2012. As part of the land-use mapping process, areas of forest destocking (both harvesting and deforestation) will be identified. These areas will be assessed for land-use change (deforestation) using oblique aerial photography taken from a light aircraft as was completed in previous years.
- Other ongoing mapping improvements include the integration of mapping information from the NZ ETS and other Ministry for Primary Industries forestry schemes, and improvements to the 2008 land-use map based on the latest Land Cover Database (LCDB3).
- LUCAS is undertaking improvements to the Soils Carbon Monitoring System, including collection of soil carbon data for under-represented land uses, and refinements to the model. The results from these analyses will further improve the information to estimate soil carbon changes with afforestation and deforestation in future projections.

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