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Manatū Ahu Matua

A guide to

Carbon Look-up Tables
for Forestry in the Emissions Trading Scheme

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About this Guide

A Guide to Carbon Look-up Tables for Forestry in the Emissions Trading Scheme provides practical advice on using the carbon look-up tables to calculate the amount of carbon stored in forests that are registered in the Emissions Trading Scheme (ETS).

Carbon Look-up Tables can either be default carbon tables provided in the Climate Change (Forestry Sector) Regulations 2008; or participant-specific carbon tables generated from information collected on the participant's registered post-1989 forest land under the Field Measurement Approach (FMA). All examples in this guide use the default carbon tables provided in the Regulations.

The default carbon tables specified in Regulations are reproduced in Appendix 2 of this Guide; these are accurate at the date of publication. As the default carbon tables are subject to change if the Regulations are amended, the tables in Appendix 2 must not be relied on for the preparation and submission of any required emissions returns.

This guide provides general guidance only, and does not purport to give advice regarding specific circumstances in relation to the ETS, New Zealand's climate change legislation in general, or the particular circumstances of individual land and forest owners.

Legislation and Regulations

The legal requirements relating to forestry in the ETS are set out in:

- Climate Change Response Act 2002 (the Act); and
- Climate Change (Forestry Sector) Regulations 2008 (the Regulations).

These are available at **www.legislation.govt.nz**.

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1. Introduction

Once forest land is registered in the Emissions Trading Scheme (ETS), forest carbon stocks will need to be calculated as follows:

- for an area of post-1989 forest land, if the participant wishes (or is required) to file an emissions return to determine the change in carbon stocks; or
- for an area of pre-1990 forest land that has been deforested, the participant is required to surrender units equal to the forest carbon stocks prior to deforestation.

For post-1989 forest land, the emissions return submitted by a participant requires values for forest carbon stocks at the beginning and end of the return period. For deforestation of pre-1990 forest land, the emissions return requires only a single value for forest carbon stocks: those in the year that the forest clearing, associated with the deforestation, occurred.

This guide explains how to calculate forest carbon stocks for a given year using carbon look-up tables. Carbon look-up tables are either the default carbon tables of carbon stocks provided in the Climate Change (Forestry Sector) Regulations 2008, or participant-specific carbon tables generated using the Field Measurement Approach (FMA). All the examples in this guide use the default carbon tables provided in the Regulations; however, the rules and calculations that are demonstrated apply equally to participant-specific carbon tables.

1.1 Other Important Information

Before reading the remainder of this document, you should be familiar with information given on MPI's website at **http://www.mpi.govt.nz/funding-and-programmes/forestry/emissions-trading-scheme/.** This provides explanations of key concepts and definitions that have special meaning under the Act and the Regulations. The more important definitions are reproduced here in the Glossary. A complete list of definitions can be found in the Act or Regulations.

2. Carbon look-up tables

2.1 What are carbon look-up tables?

Carbon look-up tables are a series of pre-calculated values of forest carbon stocks, by age, for a given forest type. The carbon stock values are expressed in units of tonnes of CO_2 per hectare. The values are equivalent to the weight of CO_2 that is removed from the atmosphere and stored in the forest during growth. This weight of CO_2 is the same as that which would be released back to the atmosphere if the forest fully decayed.

The forest carbon stock values in the carbon look-up tables include carbon in all components of a forest: that is, in the stem, branches, leaves and roots, and in the coarse woody debris and fine litter on the forest floor.

For post-1989 forest land, a separate set of tables provide the emissions from decay over time of the coarse woody debris, stumps, roots and other woody residues that remain after thinning or harvest.

The term carbon look-up tables is used in this guide as a general term to refer to either of default carbon tables or participant-specific carbon tables – whichever is required by the Regulations.

2.2 Default carbon tables

Pre-1990 forest land participants (those that have notified the EPA that they are deforesting) are required to use the default carbon tables in Schedule 4 of the Regulations. Post-1989 forest land participants with less than 100 hectares of land registered in the ETS, or in the Permanent Forest Sink Initiative (PFSI), are required to use default carbon tables provided in Schedule 6 of the Regulations.

As mentioned above, the default carbon tables consist of a series of pre-calculated values of forest carbon stocks, by age, for a given forest type. As there is sufficient information on regional growth rates available for *Pinus radiata*, the default carbon tables for that species are also differentiated by region.

Using the default carbon tables to assess forest carbon stocks is simple and low-cost, however, they are not specific to an individual participant's forest.

The default carbon tables may be revised from time to time as new information comes available.

2.3 Participant-specific carbon tables from the FMA

Those with 100 hectares or more of post-1989 forest land registered in the ETS, or in the PFSI[1], are required to use participant-specific carbon tables generated from the FMA information.

More information on the FMA, when participant-specific carbon tables must be used, and how the participant-specific carbon tables are generated, is provided in A *Guide to Field Measurement Approach for Forestry in the Emissions Trading Scheme*.

2.4 What forest types are carbon look-up tables available for?

The carbon look-up tables cover five different forest types:

- *Pinus radiata*;
- Douglas fir;
- exotic softwoods;
- exotic hardwoods;
- indigenous forest.

Pinus radiata and Douglas fir are covered by the carbon look-up tables as discrete species because good quality data on growth rates and models for these species under New Zealand conditions are available. All other exotic species (that is, those that do not occur naturally in New Zealand or have not arrived in New Zealand without human assistance) are grouped into two generalised carbon look-up tables – exotic softwoods and exotic hardwoods.

All indigenous forest species are covered within the single generalised forest type, indigenous forest.

What are exotic hardwoods or softwoods?

The Regulations provide definitions of exotic softwoods and hardwoods, based on their botanical classification. Exotic softwoods are defined as exotic forest species in the class *Coniferopsida* (gymnosperms), other than *Pinus radiata* or Douglas fir. Exotic hardwoods are defined as exotic forest species in the class *Magnoliopsida* (angiosperms). A list of common exotic hardwood and softwood species found in New Zealand is given in Table 1.

1 Subject to the specific covenant version: the FMA is required for those with 100 hectares or more in total in approved PFSI covenant(s). ETS and PFSI areas are considered separately for the purpose of FMA participation.

Table 1: Examples of common exotic hardwoods and softwoods found in New Zealand

Softwoods	Hardwoods
• Pines *Pinus* species	• Oak *Quercus* species
• Firs *Abies* species	• Ash *Fraxinus* species
• Douglas-fir *Pseudotsuga menzesii*	• Elm *Alnus* species
• Spruces *Picea* species	• Eucalypts *Eucalyptus* species
• Cypresses *Cupressus* species	• Tasmanian blackwood *Acacia melanoxylon*
• Leyland cypress X *Cupressocyparis leylandii*	• Acacia *Acacia* species
• Redwood *Sequoia* species	• Poplar *Populus* species

2.5 How have the default carbon tables been developed?

The carbon stock values in the exotic forest default carbon tables are based on well-established forest growth modelling techniques. These techniques are widely used by the New Zealand forestry sector to predict the increase in stem volume in forests over time. Stem volume is converted to whole-tree carbon stocks using standard conversion factors established from scientific studies on New Zealand forests. The decay rates for harvest residues and thinnings are also taken from such studies.

The particular growth models used to generate default table values for the main forest species in New Zealand, *Pinus radiata* and Douglas fir, have been directly calibrated against measurements from a range of sites throughout the country. For the less common exotic species, less data are currently available. This has meant that the default table for all exotic hardwoods had to be based on the single most robust growth model currently available: that for *Eucalyptus nitens*. For softwoods other than *Pinus radiata* and Douglas fir, the default table is based on the *Pinus radiata* growth model, but adjusted to account for the slower average growth rates of non-radiata species.

For indigenous forest, values of carbon stocks used to generate the default carbon tables have been taken from areas of regenerating indigenous shrublands. Shrublands represent the first step in the progression to indigenous forest, and it is areas like these that will first enter the ETS or PFSI. Data for regenerating shrublands are dominated by the forest species manuka/kanuka, as this shrubland type accounts for about 70 percent of the total regenerating indigenous area in New Zealand. The tables represent the average increase in carbon stocks on a given hectare of land since the time regeneration first began, following a land use change which has allowed an area of non-forest land to become forest land.

Natural regeneration of indigenous shrublands tends to result initially in a patchy or clumped vegetation cover, with the limited data available indicating that it takes about 10 years for a complete cover of shrubland to occur. The indigenous default carbon tables allow for this gradual expansion in vegetation cover over time.

2.6 How do the default carbon tables allow for different pruning and thinning regimes?

The stocking, thinning and pruning management regime for a forest has a substantial influence on the volume and quality of individual logs. However, the total carbon stocks in a forest over a whole rotation are less affected by the management regime than is log quality: that is, whether the carbon resides in more but smaller logs, or fewer but larger logs, makes little difference. Also, when taken over an entire rotation, and considering carbon in both live branches and dead branches on the forest floor, different pruning regimes make practically no difference to total forest carbon stocks.

The main variable, other than growth conditions, that controls forest carbon stocks at any given time during a rotation is therefore the thinning regime and decay of thinnings residues. The default carbon

table values for *Pinus radiata* and Douglas fir forests were compiled from growth models run for the thinning regimes commonly used in New Zealand. The model outputs were averaged according to statistics on the proportion of existing exotic forest area under the different thinning regimes, and by region for *Pinus radiata*.

The thinning regime assumed for exotic softwoods, other than *Pinus radiata* and Douglas fir, was the same as the nationally averaged regime for *Pinus radiata*. For exotic hardwoods, it is assumed no thinning occurs, consistent with the fact that the growth model for *Eucalyptus nitens* assumes stands are not thinned.

The national average carbon sequestration values for indigenous forest assume there is no pruning or thinning. The values do, however, implicitly account for both the enhanced natural mortality that is generally present in naturally regenerated stands, and for the decay of the resultant dead wood.

2.7 Do the default carbon tables predict the growth of my particular forest?

The values in the default carbon tables reflect growth rates for typical forests in regionally or nationally averaged environments, under average forest thinning and pruning regimes. It is not possible to provide default carbon tables that are site specific, because sufficient data to calibrate the growth models are not available.

Trees in some locations will therefore grow faster than the default carbon tables predict, for example, where trees are planted on a warmer site with better soil moisture than the average conditions in the regional or national datasets. Conversely, some trees will grow more slowly than predicted by the default carbon tables, because site conditions are poorer than the regional or national average. However, the growth models will accurately represent the average growth of a particular species (or group of species, as appropriate) at a national scale – or at a regional scale in the case of the *Pinus radiata* default carbon tables.

There may also be differences between the carbon stock values predicted by the default carbon tables and those for a particular forest because of differences in the thinning regime. However, these are not expected to be large when averaged over a typical rotation.

The main advantage of using the default carbon tables is that carbon stocks can be determined at low cost and without a forest inventory – although the carbon stocks obtained from the default carbon tables will not be as accurate in some cases as those obtained using the FMA measurement-based approach.

3. Using carbon look-up tables to estimate forest carbon stocks

3.1 When do I use a carbon look-up tables to assess forest carbon stocks?

For post-1989 forest land the carbon look-up tables must be used to:

- calculate the forest carbon stocks when filing an emissions return; or
- calculate the forest carbon stocks on ceasing to be a participant; on the transmission of an interest in forest land registered in the ETS; or when transferring registration on expiry or termination of a forestry right, lease or Crown Conservation Contract.

For all pre-1990 forest land the default carbon tables must be used to calculate the reduction in forest carbon stocks that arises from deforestation; that is, there is no FMA for pre-1990 forests.

3.2 Why are there different carbon look-up tables for pre-1990 and post-1989 forests?

Carbon stocks for pre-1990 forest land (without an exemption) only need to be calculated in the case when greater than 2 hectares is deforested in a commitment period; and not in the case of harvesting with re-establishment.

The pre-1990 forest land default carbon tables assume deforested areas comprise second or subsequent rotation forests. The emissions liability is accounted as the total carbon stocks at the time of deforestation; that is, all the carbon is assumed to be instantly emitted to the atmosphere.

Use of the carbon look-up tables to calculate forest carbon stocks in pre-1990 forests is considered in detail on page 17 onwards, complete with worked examples.

Calculation of carbon stocks for post-1989 forests must allow for a wider range of circumstances: first rotation forest growth, deforestation/withdrawal from the ETS, and harvesting with re-establishment. In the latter case, the carbon in the harvest residues from the previous rotation is accounted for in separate tables, and is assumed to decay at a constant rate over 10 years.

Use of carbon look-up tables for estimating the change in post-1989 forest carbon stocks over time (for forests continuing in the ETS), or for post-1989 forests that are deforested or voluntarily withdrawn from the ETS, is considered in detail on page 18 onwards, complete with worked examples.

4. Information needed about a forest

4.1 Information requirements: a summary

To use a carbon look-up table to calculate carbon stocks for a given area of forest land, you need the following information:

- whether the area is a pre-1990 or post-1989 forest land;
- pre-1990, the area cleared in the previous calendar year;
- the forest type on each area of forest land;
- if required to use the default carbon tables for the forest type of *Pinus radiata*, the region the forest land is located in;
- the age of the forest type at the time carbon stocks are to be determined; and
- if the area is a second or subsequent rotation post-1989 forest, the previous forest type and its age at harvest; and if the previous forest type was *Pinus radiata*, the region.

The Act requires all records used as the basis for determining forest land area, forest age, forest type and forest carbon stocks be kept for at least 20 years after they are first used.

4.2 Determining whether an area of forest is pre-1990 or post-1989 forest land

Information on classifying an area of forest as pre-1990 or post-1989 forest land is provided in the *An Overview of Forestry in the Emissions Trading Scheme* at **http://www.mpi.govt.nz/growing-and-producing/forestry/forestry**-in-the-emissions-trading-scheme/.

If the land registered in the ETS is post-1989 forest land, the geospatial mapping information submitted at registration must also have defined which Carbon Accounting Area (CAA) each mapped area of forest land belongs to. Information on assigning forest land to CAAs can be found in *A Guide to Mapping Forest Land for the Emissions Trading Scheme* at **http://www.mpi.govt.nz/growing-and-producing/forestry/forestry-in-the-emissions-trading-scheme/mapping-forest-land-in-the-ets/.**

4.3 Determining the forest type for an area of forest land

To the carbon look-up tables, an area of forest land must be classified as one of five forest types: *Pinus radiata*, Douglas fir, exotic softwoods, exotic hardwoods or indigenous forest[2]. This classification is straightforward if all species present in a given area belong to a single forest type.

Where mixed species from different forest types occur, you may need to identify the predominant species: that is, the single species with the largest basal area. The predominant species then defines the forest type for an area with mixed species. Determination of the predominant species in areas of mixed species must be performed on a hectare-by-hectare basis.

An example of determining the predominant species for an area of forest land is given below. Further examples can be found on pages 16 to 23 of this guide.

Example: Determining predominant species

An area of pre-1990 forest land in Northland comprises mixed (that is, intermingled) trees of three different species: *Pinus radiata*, redwood and *Pinus muricata*. The basal area in these species is estimated as 60 percent, 30 percent and 10 percent of the total on each hectare, respectively. The predominant species is therefore *Pinus radiata*, and carbon stocks are estimated using the pre-1990 *Pinus radiata* default carbon table (Appendix 2, Schedule 4, Table 1, column 2).

4.4 Determining the region for *Pinus radiata* forests

FMA participants do not need to determine region for their areas of *Pinus radiata* forest type. As part of the FMA process, they receive a single set of participant-specific carbon tables averaged for all of their *Pinus radiata* forests.

Participants required to use the default carbon tables for *Pinus radiata* must identify the region for each area of forest land. There are separate default carbon tables for *Pinus radiata* for nine regions: Auckland, Bay of Plenty, Canterbury/West Coast, Gisborne, Hawke's Bay/Southern North Island, Nelson/Marlborough, Otago, Southland and Waikato/Taupo. The location of these regions is specified in terms of district and city boundaries, and is given in Schedule 1 of the Regulations and reproduced in Appendix 2.

2 It is very unusual for pre-1990 forest land to have a forest type of indigenous forest. Only if pre-1990 forest land (i.e. comprising exotic forest species) was cleared after 31 December 2007, and indigenous forest species established in their place, would this be the case.

4.5 Determining the age of forest species

The age of the trees in a forest type is calculated differently in different cases, as outlined below (some aspects of which are described in more detail in later sections):

1. For post-1989 forests, it is the age relating to the start and end of the period for which an emissions return is being filed that must be determined.
2. For pre-1990 and post-1989 forests that are cleared, it is the age in relation to the year of clearing (no matter when in the year clearing occurred) that must be determined.
3. For planted forest species, the age is the number of years from the year of planting[3], no matter when in the year planting occurred.
4. If forest species regenerate after a previous harvest: the species are treated as if they regenerate in the year immediately following the year of harvest. This is because it would most usually be exotic forest species that regenerated, and these would likely only be of similar size to planted trees (which the carbon look-up tables assume) in the year after regeneration.
5. For mixed (intermingled) forest types, age and forest type are determined according to the predominant species:

- If the predominant species is an exotic forest species, the forest age is calculated as the basal area-weighted average age of all forest species belonging to the same forest type as the predominant species.
- If the predominant species is a regenerating indigenous forest species, age is calculated as described below (or less commonly, case 4 above if regeneration is after a previous harvest).

6. Determining the age of regenerated trees

- The age to be determined is that of the oldest trees that have regenerated following the land-use change which has allowed an area of non-forest land to become forest land. If the site being considered is one in which regeneration conditions are favourable, it will usually be sufficient to assume the trees regenerated in the year after the land-use change. However, in other cases it is likely to be necessary to determine age by ring-counting of a core sample, or by felling several trees of similar diameter to the larger of those in a particular permanent sample plot but located somewhat outside of the plot perimeter.
- Areas with regenerated trees may contain older trees that established significantly before the change in land management that allowed an area of former non-forest land became forest land. Typically, these older trees will be remnants from some earlier cycle of land clearance, which have acted as seed sources once the change in land management occurred that promoted the present conversion to forest land. It is not appropriate to use the date of establishment of such older seed-source trees to determine the age of first regeneration of trees in a sample plot.

Note also that:

- If the forest age calculated is other than a whole number: ages must be rounded to the nearest whole number (that is, rounded up if a decimal of 0.5 or greater and down otherwise).
- Whenever an area of forest land has mixed forest species of more than one forest type, then the Regulations require the predominant species to be determined (on a hectare-by-hectare basis if the species comprising the forest types are not evenly mixed). If the proportion of forest species, or the age of trees, varies within a given area, then both the predominant species and age may vary hectare by hectare.

3 Years spent in a forest nursery are not counted.

- Fortunately, species and age usually only vary hectare by hectare when forest land is naturally regenerated post-1989 indigenous forest. In that case, the age of all trees is determined from the single date of first regeneration after the land use change which promoted conversion to forest land, irrespective of when they regenerated – as described above.
- The only time that region becomes an important consideration in determining forest age is if the forest area spans more than one region and *Pinus radiata* of mixed age occurs in varying proportions throughout the area. It is possible in this situation that the age and predominant species of the forest may vary hectare by hectare. In this case, the forest area should be subdivided by region (as per Appendix 1) as a first step, and each region then considered separately.

Specific rules covering determination of tree age in the situations outlined above are given in the remainder of this section, together with worked examples. Further examples of determining tree age for use with the carbon look-up tables can be found in Sections 5 and 6 of this guide.

Determining forest age when using the pre-1990 forest default carbon tables

For pre-1990 forest land, the age of a tree is determined under the Act and Regulations by two rules:

i) The age of a tree is the number of years from the year of planting[4] or regeneration of the tree to the year of clearing of the tree, no matter when in the relevant year the tree was planted, regenerated or cleared.

ii) If the trees cleared from pre-1990 forest land as part of deforestation are less than nine years old, then the emissions are calculated on the basis of the age and (predominant) species of the oldest trees cleared from each hectare of pre-1990 forest land during the previous nine years. For this reason, the default carbon tables for pre-1990 forests start at age nine years.

This latter rule requires that:

- deforestation liabilities are calculated based on carbon stocks in the previous forest, if deforestation of the current forest takes place less than nine years after the previous forest was harvested; or
- the forest established after the harvest of a previous forest must be allowed to grow for not less than nine years before deforesting, and the liability arising from deforestation of at least nine-year-old trees must then be met.

Examples of determining tree age for single and mixed forest species are given below. Further examples can be found on pages 16 to 23 of this guide.

Examples: Tree age at the time of deforestation of pre-1990 forest land

a) A first rotation Douglas fir forest was planted in September 1985 and is deforested in February 2013. Applying rule (i) above, the age of the forest used to calculate the deforestation liability using default carbon tables is 28 years.

b) A *Pinus radiata* forest was planted in the Auckland region in June 1968. It was harvested in June 2008 at age 40 and Douglas fir seedlings were planted soon after. The land therefore remained pre-1990 forest land. In November 2012, the Douglas fir forest was cleared and the area changed to dairy farming: that is, deforestation occurred. The Douglas fir trees are four years old at the time of deforestation. However, under rule (ii) above, the deforestation liability that exists is calculated using the default carbon tables for the previous rotation *Pinus radiata* forest at an age of 40 years. The resulting liability is very large: 1 090 tonnes CO_2 per hectare for an Auckland forest (default carbon table data from Appendix 2, Schedule 4, Table 1, column 2).

4 Years spent in a forest nursery are not counted.

c) For example b) above, consider that the harvest of the Douglas fir forest is delayed until January 2017. The Douglas fir trees are then nine years old under rule (i). Rule (ii) above no longer applies, and the deforestation liability that exists is calculated using the default carbon tables for Douglas fir forest for an age of nine years. The resulting liability is much smaller than for example B: 131 tonnes CO_2 per hectare (default carbon table data from Appendix 2, Schedule 4, Table 2, column 2).

Determining forest age when using the post-1989 forest carbon look-up tables

For post-1989 forest land, the age of a tree is determined under the Act and Regulations by the rules given below. The rules relate age to key determining events, and ensure that tree age is a whole number – as required when using the carbon look-up tables.

The age of a tree is the number of years from the year of planting[5] or since regeneration began (no matter when in that year the tree was planted or is considered to have regenerated), to one of the following key events:

- the year of commencement of an emissions return period, if calculating the opening carbon stocks for that return period; or
- the year of clearing of the tree, no matter when in that year the tree was cleared, if calculating:
  - the reduction in carbon stocks due to harvesting or deforestation; or
  - the decay of harvest residues that result from clearing; or
- the year in which any event occurs that under the Act requires or allows a participant to file an emissions return[6], if that event occurs before 31 December of that year; or
- the year after the end of an emissions return period, if an emissions return that covers a full calendar year is being filed.

Examples of determining tree age when single exotic forest species are present, or the forest type is indigenous, are given below. Examples of determining tree age when mixed species are present are given in the following sub-sections. Further examples can be found on pages 21 to 23 of this guide.

Example: Tree age at the time of commencement and end of an emissions return period

A Douglas fir forest is planted in June 1992. The owner joins the ETS in June 2012, and files a first emissions return in the first quarter of 2013. The return covers the period 1 January 2008 until 31 December 2012. Under the rules for determining the age of trees on post-1989 forest land:

- The year of planting of the trees is 1992.
- The year of commencement of the emissions return period is 2008, and the age of the trees in that year is: 2008 – 1992 = 16 years.
- The emissions return period finishes on 31 December 2012, so the year used to determine age at the end of the emissions return is the year after, that is, 2013. The age of the trees at the end of the emissions return period is: 2013 – 1992 = 21 years.

Example: Tree age at the time of commencement and end of an emissions return period, with harvesting and replanting of part of the forest during the return period

A 40.1 hectare *Pinus radiata* forest is planted in the Auckland region in June 1992, but in May 2010 the owner decides to harvest half of it and immediately plant Tasmanian blackwood. The owner joins the ETS in June 2012, and files a first emissions return in the first quarter of 2013 that covers the period 1 January 2008 until 31 December 2012.

5 Years spent in a forest nursery are not counted.
6 That is, any emissions return other than a return under section 189(3) of the Act.

Under the rules for determining the age of trees on post-1989 forest land:

- The year of planting of the *Pinus radiata* is 1992.
- The year of commencement of the emissions return period is 2008, so that the age of the *Pinus radiata* trees at that time is: 2008 –1992 = 16 years.
- The year that half of the *Pinus radiata* forest was harvested is 2010, irrespective of when in that year the trees were cleared. The age of those trees that were harvested is: 2010 – 1992 = 18 years.
- The year that half of the post-1989 forest land was re-planted with Tasmanian blackwood is 2010, irrespective of when in that year the new trees were planted. The age of those trees at the end of the emissions return period is therefore: 2013 – 2010 = 3 years.
- The age at the end of the emissions return period of the *Pinus radiata* trees that were not harvested in 2010 is: 2013 – 1992 = 21 years.

Example: Age of naturally regenerated indigenous forest species at the commencement and end of an emissions return period

An owner intends to regenerate an area into indigenous forest species. The area is fenced, and stock were removed in 2000. Inspection in late 2000 indicated no regeneration, but by late Spring in 2001 some seedlings of indigenous forest species had established and were expected to survive. In early 2008 a survey showed sufficient seedlings of indigenous forest species had become established over the whole area for the land to be eligible as post-1989 forest land. The owner joins the ETS in 2009, and completes their first emissions return in the first quarter of 2013 (for the period 1 January 2008 to 31 December 2012).

Under the rules for determining the age of the trees:

- The year regeneration began following the land use change is 2001.
- The year of commencement of the emissions return period is 2008, and the age of the trees in that year is: 2008 – 2001 = 7 years.
- The emissions return period finishes on 31 December 2012, so the year used to determine tree age at the end of the emissions return is the year after; that is, 2013.
- The age of the trees at the end of the emissions return period is therefore: 2013 – 2001 = 12 years.

Determining forest age when there are mixed tree species and ages

In this situation, one of the following will apply. If a hectare of forest land comprises:

- Mixed (that is, intermingled) trees of the same forest type, but with different ages, the forest age is taken as the weighted (by basal area) average of the trees in that area.
- Mixed trees belonging to different forest types, and perhaps also with different ages: the predominant forest species must first be determined (on a hectare-by-hectare basis if applicable), and the forest age is taken as the weighted (by basal area) average age of all tree species in the same forest type as the predominant species (also on a hectare-by-hectare basis if applicable).

If the calculations above result in a forest age that is not a whole number, then the age is rounded to the nearest whole number (that is, rounded up if a decimal of 0.5 or greater, and down otherwise).

Example: Single species forest with mixed age (in a single region)

In June 2010, a forest owner in Northland clears an area of *Pinus radiata* forest that comprises evenly mixed (that is, intermingled) 15-year-old trees and 30-year-old trees. The 15- and 30-year-old trees account for 30 percent and 70 percent, respectively, of the total basal area. The weighted-average age for this forest type is:
weighted-average age = (30 years x 0.7) + (15 years x 0.3) = 25.5 years.

Because the age is not a whole number it must be rounded, in this case upwards, and becomes 26 years.

Example: Mixed species forest with mixed age and a single forest type

A pre-1990 forest comprises evenly mixed trees of two different species: 60 percent of the basal area is 30-year-old redwood and 40 percent is 15-year-old *Pinus muricata*. Redwood is therefore the predominant species, and both are exotic softwoods. The weighted-average age is calculated on the basis of all species that belong to the same forest type as the predominant species:
weighted-average age = (30 years x 0.6) + (15 years x 0.4) = 24 years.

Example: Mixed species forest with mixed age and mixed forest types

A pre-1990 forest comprises evenly mixed trees of the following species: 60 percent of the basal area is 30-year-old *Eucalyptus nitens*, 30 percent is inter-planted 25-year-old Eucalyptus fraxinoides and 10 percent is young, naturally regenerated kanuka. The predominant species is therefore *Eucalyptus nitens*, and the forest types are exotic hardwoods and indigenous forest. In the case of forest areas comprising two or more forest types, the (weighted) average age is calculated on the basis of those species in the same forest type as the predominant species only.

Expressed as a percentage of the exotic hardwoods forest type only, the basal area of 30- and 25-year-old Eucalyptus trees account for 66.7 percent and 33.3 percent, respectively, of the total basal area of exotic hardwood trees. The weighted-average age of the predominant forest type is:

weighted-average age = (30 years x 0.667) + (25 years x 0.333) = 28.3 years.

Because the age is not a whole number it must be rounded, in this case downward, and becomes 28 years.

Using the carbon look-up tables for forest ages greater than listed in the tables

If the age of the forest type exceeds the last age given in a particular carbon look-up table, then the carbon look-up table value corresponding to the last age must be used.

4.6 Applying carbon look-up tables to an area of mapped forest land

Prior to calculating carbon stocks using carbon look-up tables, you must have submitted geospatial mapping information defining the area of pre-1990 or post-1989 forest land. The geospatial mapping information comprises a series of forest land polygons and, in the case of post-1989 forest land, each polygon will have been assigned to a CAA. For an emissions return, reporting of carbon stocks change is performed at the total forest land level for deforested pre-1990 forest land, or for each CAA for post-1989 forest land.

If an area of forest land comprises mixed tree species, perhaps belonging to different forest types or with mixed ages, then values are taken from the carbon look-up tables according to the "predominant species" (species with the largest basal area), and the average age (derived from all trees belonging to

the same forest type as the predominant species, if applicable) as illustrated in the examples earlier. If the (predominant) species is *Pinus radiata*, and the forest area spans multiple regions, then it is necessary to calculate the carbon stocks separately for each region.

You should review the information you hold for areas of forest land with mixed forest species, forest types, or ages to ensure it is sufficient to enable the carbon look-up tables to be applied, before attempting to file an emissions return.

If when using the default carbon tables, the (predominant) species is *Pinus radiata* over an area spanning multiple regions, then it is necessary to calculate the carbon stocks separately for each region. In this case it is likely to be simpler if mapped forest land polygons do not cross regional boundaries.

Identifying sub-areas

To apply the carbon look-up tables, first identify sub-areas: areas of forest land of one or more hectares that have a unique combination of the parameters on which the relevant carbon look-up tables are based. These parameters are:

i) For pre-1990 forest land: areas with the same forest type and age; and region if the forest type is *Pinus radiata*.
ii) For post-1989 forest land:
- areas with the same forest type and age; and region[7] if the forest type is *Pinus radiata*;
- the same CAA; and
- if the area has decaying residual biomass[8] from a previous rotation forest, the previous forest must have comprised trees that were:
  - the same forest type; and
  - the same age when cleared; and
  - cleared in the same year; and
  - located in the same region, if the trees cleared were *Pinus radiata*.

The area in hectares of a sub-area must be rounded to one decimal place before being used in subsequent calculations (0.05 hectares becomes 0.1 hectares). Note that a sub-area may actually comprise multiple discrete areas, within an area for which emissions or removals are being reported; that is, within either a deforested area cleared in the same year in the case of pre-1990 forest land, or a CAA for post-1989 forest land. In these situations the area in hectares of each discrete area comprising each sub-area is added together before rounding.

Example: Sub-areas within post-1989 forest land

A post-1989 forest owner registers an area of 190.63 hectares of *Pinus radiata* in the ETS. It comprises two stands of 15 year old trees (of 50.15 and 49.17 hectares respectively), separated by a stand of 10 year old trees (of 91.31 hectares). All stands are in the same CAA. The two stands of 15 year old trees therefore belong to the same sub-area, which has a rounded area of 99.3 hectares. The 10 year old trees are in a separate sub-area, with a rounded area of 91.3 hectares.

7 Region is not relevant for participant-specific carbon look-up tables.
8 Above-ground residual wood and below-ground roots are treated as decaying over 10 years from the year of clearing.

A step-by-step procedure for sub-area determination

The following procedure is suggested for determining the extent of each sub-area for the purpose of preparing an emissions return for an area of post-1989 forest land within a single CAA[9], or an area of deforested pre-1990 forest land:

i) Determine the area of forest land (in hectares, without rounding) in all mapped polygons covered by species that belong to only one of the following forest types: *Pinus radiata*, Douglas fir, exotic hardwoods, exotic softwoods or indigenous forest[10].
ii) If there are areas of the forest type *Pinus radiata*, and that area spans more than one region, then determine the area in each region (without rounding).
iii) If the area of forest land covered by a single forest type (in a given region, if applicable) includes discrete areas of forest species of more than one age[11], then determine the area of forest land for each age. If the forest species in an area comprising a single forest type are of mixed age, then the appropriate age is the basal area-weighted average age of those species. If the proportion of those species varies within the area, the average age must be determined on a hectare-by-hectare basis.
iv) Add up the unrounded areas for each sub-area – areas with a unique combination of forest type, age, and (if *Pinus radiata*) region. Round the total area of each sub-area to one decimal place (0.05 hectare is rounded up).

Any areas remaining in the mapped forest land polygons must be mixed forest types, possibly with mixed ages. Such areas are referred to as intermingled forest, and if present then:

a) Determine on the basis of the predominant forest species the area (in hectares) of forest land covered by each of the following forest types: *Pinus radiata*, Douglas fir, exotic hardwoods, exotic softwoods or indigenous forest. If the tree species are unevenly mixed, the forest type may vary within an area. If so, the predominant species and forest type must be assessed, on a hectare-by-hectare basis.
b) Once the forest type is determined, follow steps (ii) and (iii) above to determine the unrounded area in hectares of each area with a unique combination of region (if *Pinus radiata*), forest type and age.
c) Add up the unrounded areas for each sub-area – areas with a unique combination of forest type, age, and (if Pinus radiata) region. Round the total area of each sub-area to one decimal place (0.05 hectare is rounded up).

Examples of implementing this procedure under situations that ETS Participants may commonly encounter are given in Sections 5 and 6.

9 For simplicity, it is assumed that the post-1989 forest land area comprises a first rotation forest.
10 It is very unusual for pre-1990 forest land to have a forest type of indigenous forest. Only if pre-1990 forest land (i.e. comprising exotic forest species) was cleared after 31 December 2007, and indigenous forest species established in their place, would this be the case.
11 Under the Regulations, an area of regenerated indigenous forest land is considered to only ever have a single age, that of the oldest trees that regenerated following the change in land management that allowed an area of non-forest land to become forest land.

5. Using the default carbon tables to determine carbon stocks on pre-1990 forest land

5.1 The default carbon tables and how to apply them

The values in the default carbon tables for pre-1990 forest land have been calculated using the models and growth rate assumptions outlined in Section 2. A key assumption is that the forest is in its second rotation, as deforestation of most pre-1990 forests is expected to involve second rotation forests.

The default carbon tables to be used for calculating pre-1990 forest carbon stocks, when estimating deforestation emissions, are available in Schedule 4 of the Regulations and are reproduced in Appendix 2. These tables comprise:

- Table 1: Values of forest carbon stocks for *Pinus radiata*, by age and region.
- Table 2: Values of nationally averaged forest carbon stocks for Douglas fir, exotic softwoods, exotic hardwoods and indigenous forest, by age.

All carbon stocks are given in units of tonnes of CO_2 per hectare. A default carbon table for the deforestation of indigenous forest established before January 1990 is included for completeness, though this is expected to be a rare event.

The total amount of carbon considered to be emitted to the atmosphere when an area of pre-1990 forest is deforested is calculated using the following formula:

$$E = A \times C$$

where:

E = the emissions due to deforestation of an area of forest land.
A = an area of deforested pre-1990 forest land in a sub-area (in hectares, to one decimal place)
C = the value of carbon stocks from the default carbon tables in Schedule 4, for the given forest type, age and region (if applicable) in the sub-area.

In other words, the total amount of carbon emitted from a pre-1990 forest of a given forest type, age (and region, if applicable) is equal to the total area deforested multiplied by the appropriate carbon stock value[12] taken from the default carbon tables. The total emissions reported in an emissions return are rounded to the nearest whole number (0.5 hectare is rounded up).

5.2 Examples of calculating forest carbon stocks using the default carbon tables

Deforested areas comprising single or evenly-mixed forest species

This will be the most common situation. The entire area can be readily classified as a single forest type, based on the predominant forest species if species are mixed. Subdivision by age is the next step, based on the average age of those forest species comprising the nominated forest type if species are mixed. If the predominant species is *Pinus radiata*, and the area spans more than one region, subdivide the area by region first, before subdividing by age. Emissions can then be calculated for each sub-area, the calculated emissions summed for the total forest area, and the resulting total emissions rounded to a whole number and reported.

12 Including for decay of harvest residues of the previous rotation, while applicable.

Example: Deforestation of a single pre-1990 forest stand

A pre-1990 forest owner deforests 88.34 hectares of 34-year-old Douglas fir during a year, which therefore comprises a single sub-area. To calculate the emissions as a result of the deforestation, use Table 2 of Appendix 2 – go to the column headed Douglas fir and read off the carbon stock value corresponding to an age of 34 years.

Thus: A (the area) = 88.3 hectares (rounded to 1 decimal place)
C (the default table value) = 629 tonnes CO_2 per hectare; and
E (the deforestation emissions) = 88.3 x 629 = 55 540.7 tonnes CO_2
= 55 541 tonnes CO_2 (rounded to whole tonnes).

Example: Deforestation of an area of pre-1990 forest land comprising stands with different forest species, forest types, and ages

A pre-1990 forest owner deforests an area of 185.69 hectares of forest in Northland during a year. The owner's records show the forest land comprises three stands: 100.13 hectares of 28-year-old *Pinus radiata*; 55.52 hectares of 28-year-old Douglas fir; and 30.04 hectares of evenly mixed 12-year-old *Eucalyptus nitens*, nine-year-old Eucalyptus fraxinoides and a few old kanuka of unknown age. Field inspection shows the predominant species in the evenly mixed stand is *Eucalyptus nitens* and the forest type of the mixed stand is exotic hardwoods. Inspection also shows that the average ratio of the basal area of the two exotic hardwood species, *Eucalyptus nitens* to *Eucalyptus fraxinoides*, is 3:1. (the kanuka are ignored as they are not species belonging to the forest type of the predominant species).

Step 1: Calculate the weighted-average age of the mixed eucalypt/kanuka stand, which is done on the basis of the species comprising exotic hardwoods only:

Weighted-average age = (12 years x 0.75) + (9 years x 0.25) = 11.25 years.

The age must be rounded to a whole number and becomes 11 years.

Step 2: Calculate the total carbon stocks for the forest land area at the date of clearing, as the rounded sum of the stocks in each sub-area.

The appropriate default carbon table values are taken from Appendix 2: column 2 in Table 1, column 2 in Table 2 and column 3 in Table 2 — for the *Pinus radiata*, Douglas fir and predominantly exotic hardwoods stands, respectively, which comprise 3 sub-areas:

100.13 hectare *Pinus radiata* stand, 28 years old:
A (the area) = 100.1 hectares (rounded to 1 decimal place)
C (the default table value) = 807 tonnes CO_2 per hectare; and
E (the deforestation emissions) = 100.1 x 807 = 80 780.7 tonnes CO_2

55.52 hectare Douglas fir stand, 28 years old:
A (the area) = 55.5 hectares (rounded to 1 decimal place)
C (the default table value) = 475 tonnes CO_2 per hectare; and
E (the deforestation emissions) = 55.5 x 475 = 26 362.5 tonnes CO_2

30.04 hectare exotic hardwoods stand, 11 years old:
A (the area) = 30.0 hectares (rounded to 1 decimal place)
C (the default table value) = 337 tonnes CO_2 per hectare; and
E (the deforestation emissions) = 30.0 x 337 = 10 110 tonnes CO_2
Hence total emissions on deforestation = 80 780.7 + 26 362.5 + 10 110 tonnes CO_2
= 117 253 tonnes CO_2 (rounded to whole tonnes)

Deforested areas comprising unevenly mixed forest species

Applying the default carbon tables in such areas is relatively complex if variation in the species mix results in spatial variation in the predominant species (and therefore forest type) and/or in the (based on area weighted) average age of the forest type. In such cases, the forest type and/or average age must be determined on a hectare-by-hectare basis. Once this is done, emissions can then be calculated for each sub-area in the same manner as areas with a single species and uniform age. The total emissions can then be calculated for all sub-areas in the deforested area, rounded to a whole number, and reported.

For areas with unevenly mixed forest species, deforestation emissions are determined by:

i) If *Pinus radiata* is present in the forest area, and likely to be a predominant species on a given hectare, first sub-dividing the area according to region.
ii) Establishing, on a hectare-by-hectare basis, the predominant species and the forest type.
iii) Calculating the average age of the tree species in each area that belong to the designated forest type, on a hectare-by-hectare basis, as the basal area-weighted average age of those forest species that belong to the forest type.
iv) Determining the area in hectares to one decimal place for each sub-area (each unique combination of forest type, age, and region if applicable), calculate the carbon stocks for each sub-area, sum the total, and report as the emissions the total carbon stocks rounded to a whole number.

If *Pinus radiata* is present on an area of forest land, and likely to be a predominant species, calculations will usually be simpler if a participant's forest maps do not contain polygons of forest land that cross regional boundaries. Provided this is done, calculations at the sub-area level will fall under one of the examples already given above for pre-1990 forests.

6. Using carbon look-up tables to determine the carbon stocks on post-1989 forest land

6.1 The carbon look-up tables and how to apply them

As outlined in Section 2, the pre-1990 and post-1989 carbon look-up tables differ. This is because for post-1989 forest land carbon stock, calculations are required for both first and second (or later) rotation forests, and when either harvesting or deforestation occurs.

Calculations of emissions or removals for post-1989 forests are performed for each sub-area within a CAA. Rounding of area occurs at the sub-area level (recalling that a sub-area may comprise multiple discrete areas within a CAA), whereas rounding of emissions or removals occurs at the CAA level. Also note that if the forest involved is a second or later rotation forest, the definition of a sub-area requires consideration of the forest type, age and (if *Pinus radiata*) region for both the current and previous crop.

The default carbon tables for post-1989 forest land are given in Schedule 6 of the Regulations, and are reproduced in Appendix 2. They comprise:

- Table 1: Values of forest carbon stocks for *Pinus radiata*, by age and region.
- Table 2: Values of nationally averaged forest carbon stocks by age for Douglas fir, exotic softwoods, exotic hardwoods and indigenous forest.
- Table 3: Values of carbon stocks in the harvest residues (above-ground wood, including stumps and roots) for cleared *Pinus radiata* forest, by region for the tree age at which forest clearing occurred.
- Table 4: Values of nationally averaged carbon stocks in the harvest residues (above-ground wood, including stumps and roots) for cleared Douglas fir, exotic softwoods, exotic hardwoods and indigenous forest, for the tree age at which forest clearing occurred.

FMA participants receive the following carbon tables with values specific to their forest (for the forest types occurring in permanent sample plots):

- Table(s) of values of averaged carbon stocks for *Pinus radiata*, Douglas fir, exotic softwoods, exotic hardwoods and indigenous forest, by tree age.
- Table(s) of values of carbon stocks in the harvest residues for cleared *Pinus radiata*, Douglas fir, exotic softwoods, and exotic hardwoods, for the age at which forest clearing occurred.

Where FMA participants have sub-areas of a forest type for which participant-specific carbon tables have not been generated, they are required to use the default carbon tables.

All carbon stocks are given in units of tonnes of CO_2 per hectare.

Considering both measured values for decay rates in New Zealand, and ease of calculation, the carbon stocks given in the post-1989 forest carbon look-up tables for harvest residues are assumed to decay to zero at a constant rate over the 10 years following clearing.

To calculate carbon stocks in post-1989 forest land, the carbon look-up tables are used as follows:

- If the forest is first rotation – that is, there are no harvest residues from a previous forest because the forest was planted on land not previously forested – use the appropriate carbon look-up tables to determine the carbon stocks for the particular forest age and type (and if *Pinus radiata* using the default carbon tables, for the region).
- If the forest is second (or later) rotation – that is, there are harvest residues present that will have been decaying since the time of clearing of the previous forest – then determine the forest carbon stocks by:
  - calculating the carbon stocks in the second (or later) rotation forest using a value from the forest carbon look-up tables as appropriate for the forest age and type (and if *Pinus radiata* using the default carbon tables, for the region);
  - calculating the carbon stocks in the harvest residues at the time of clearing of the previous forest rotation, using a value from a harvest residues carbon look-up table appropriate for the forest type and age at the time of clearing (and if *Pinus radiata* using the default carbon tables, for the region);
  - reducing the value for carbon stocks in the harvest residues from the previous forest to account for decay of those residues since the time of harvest;
  - adding together the carbon stocks in the new second rotation (or later) forest and those remaining undecayed from the previous rotation, if any.

The steps for calculating carbon stocks given above are expressed in the following formulae. Forest carbon stocks at the commencement and end of an emissions return period due to growth in the current rotation forest are estimated by:

$$T_1 = A \times C$$

where:

T_1 = carbon stocks in an area of post-1989 forest land
A = total area of post-1989 forest land comprising a sub-area
C = the value of forest carbon stocks from Tables 1 or 2 in Schedule 6, for the given forest type, age, and region (if applicable) of the forest comprising the current rotation

Carbon stocks at the end of an emission return period in a second (or later) rotation forest due to harvest residues that remain from an earlier rotation forest are estimated by:

$$T_2 = A \times C \times (10 - T_{SC})/10$$

where:

T_2 = carbon stocks in an area of post-1989 forest land due to harvest of a previous rotation forest

A = total area of post-1989 forest land comprising a sub-area

C = the value of carbon stocks in the sub-area for the previous rotation forest obtained from Tables 3 or 4 in Schedule 6

T_{sc} = is the number of years up to 10 since the trees were cleared and is equal to the difference between:

a) the year in which the end of the emissions return period falls (or, if the emissions return period ends on 31 December, the following year); and

b) the year that the trees were cleared (no matter when in that year the trees were cleared)

Forest carbon stocks in a first rotation post-1989 forest are equal to T_1, and for a second (or subsequent) rotation forest equal to $T_1 + T_2$.

The time in years since the trees were cleared is presently counted from the year that the trees were cleared, to the year in which the end of the emission return period falls, or if the emission return period ends on 31 December, the following year[13]. In the example below, a *Pinus radiata* forest is harvested in 2014, and an emissions return is filed for the period 1 January 2013 to 31 December 2017. The number of years since clearing is calculated by subtracting 2014 from 2018, that is, 4 years.

Reporting carbon stock change in an emissions return

Carbon stocks at the opening and closing dates of an emissions return period are calculated for all sub-areas in a CAA using the formulae above (remember that the total area in hectares of a sub-area must be rounded to one decimal place). The opening and closing carbon stocks are then summed for all the sub-areas. The carbon stock change for the CAA that is reported in the emissions return is the difference (rounded to the nearest whole tonne) between the summed closing and opening stocks.

6.2 Examples of calculating forest carbon stocks using the default carbon tables

Forest land comprising single or evenly-mixed forest species

This will be by far the most commonly encountered situation. The entire area can be readily classified as a single forest type, based on the predominant forest species if species are mixed. Subdivision by age is the next step, based on the average age of the trees that comprise the nominated forest type if species are mixed. If the (predominant) species is *Pinus radiata*, and the area spans more than one region, subdivide the area by region before subdividing by age. Once this is done, opening and closing carbon stocks can then be calculated and summed for all sub-areas of forest land that comprise a given CAA. The difference between the closing and opening stocks is rounded to a whole number, and reported at the CAA level.

Example: Change in carbon stocks in a first rotation post-1989 forest stand with a single forest type

A post-1989 forest owner with 45.83 hectares of *Pinus radiata* in Northland joins the ETS in December 2012, and files an emissions return in the first quarter of 2013. The forest was planted in June 1996. To complete the emissions return, forest carbon stocks at 1 January 2008 and 31 December 2012 must be calculated. In this case, the forest is 12 years old at the start of the emissions return period. At the end of the emissions return period the forest is 17 years old (note the use of the year after the end of the emissions return period to calculate age, under the rules given in Section 4.5). Assume the entire forest area is within one CAA.

13 The definition of Tsc will be updated at the next change in Regulations to account for the emissions due to decay in a previous mandatory emissions return period.

First, the carbon stock at the start of the period (1 January 2008) is calculated. The appropriate default table values for the forest are taken from Appendix 2 (Table 1, column 2 in Schedule 6):

Thus: A (the area) = 45.8 hectares
C (the default table value) = 249 tonnes CO_2 per hectare
T_1 (the total carbon stock) = 45.8 x 249 = 11 404.2 tonnes CO_2

Second, the carbon stock at the end of the period (31 December 2012) is calculated:

Thus: A (the area) = 45.8 hectares
C_1 (the default table value) = 435 tonnes CO2 per hectare
T_1 (the total carbon stock) = 45.8 x 435 = 19 923.0 tonnes CO_2

The net carbon stock change for which the forest owner will receive New Zealand Units (NZUs) is:
19 923.0 – 11 404.2 = 8 519 tonnes CO_2 (rounded to a whole number)

Example: Change in carbon stocks in a post-1989 forest stand over a period involving harvesting and replanting

A post-1989 forest owner who has joined the ETS originally had 45.83 hectares of *Pinus radiata* in Northland planted in June 1996, and filed their first emissions return for the period up to and including 31 December 2012. The forest owner's records show the opening and closing forest carbon stocks for the 2008–2012 reporting period were 11 404.2 and 19 923.0 tonnes CO_2, respectively, and their New Zealand Emissions Unit Register (NZEUR) holding account shows that 8 519 NZUs have been issued.

In June 2014, it was decided to harvest the *Pinus radiata*, and *Eucalyptus nitens* were planted in August. It is now January 2018, and an emissions return is due for the period 1 January 2013 to 31 December 2017. Assume the entire forest area is within one CAA.

For the purposes of this calculation, the *Pinus radiata* forest is considered to be 17 years old at the start of the emissions return period, and 18 years old at the time of harvesting. The *Eucalyptus nitens* forest is four years old at the end of this period. Harvest residues from the *Pinus radiata* forest are also considered to have been decaying for four years, at the end of the period.

The value of the carbon stocks at the start of the period (1 January 2013) would be (taking the appropriate default carbon table values for an age 17 *Pinus radiata* forest from Appendix 2, Table 1, column 2 in Schedule 6):

A (the area) = 45.8 hectares
C (the default table) = 435 tonnes CO_2 per hectare
T_1 (the total carbon stock) = 45.8 x 435 = 19 923.0 tonnes CO_2

The carbon stock at 31 December 2017 is calculated as the sum of the carbon stocks in the decaying harvest residues from the *Pinus radiata* forest harvested in 2014, plus the stocks in the newly planted *Eucalyptus nitens* forest, as follows:

First, calculate the carbon stock in the newly planted *Eucalyptus nitens* forest. *Eucalyptus nitens* is classed as an exotic hardwood. The appropriate carbon default table values are taken from Appendix 2 (Table 2, column 4 in Schedule 6):

A (the area) = 45.8 hectares
C (the default table) = 34 tonnes per hectare
T_1 (the total carbon stock) = 45.8 x 34 = 1557.2 tonnes CO_2

Second, calculate the carbon remaining in the harvest residues from the *Pinus radiata* forest four years

after harvest. The appropriate carbon stock default table values are taken from Appendix 2, Table 3, column 2 in Schedule 6:

A (the area)	= 45.8 hectares
C (the default table)	= 227 tonnes CO_2 per hectare
T_{sc} (number of years since the trees were cleared)	= 4 years (2018 – 2014)
T_2 (the total carbon stock)	= A x C x (10-Tsc)/10
	= 45.8 x 227 x (10 - 4)) / 10
	= 6 237.96 tonnes CO_2

Hence, the total carbon stock at the end of the period is the sum of the carbon stock in the decaying harvest residues and the carbon stock in the newly planted trees:
Total carbon stock = 1 557.2 + 6 237.96 = 7 795.16 tonnes CO_2

The net carbon stock change in the CAA over the period is negative, as the carbon stock has decreased because of harvesting of the older *Pinus radiata* forest:

Carbon stock change	= 7 795.16 – 19 923.0 tonnes CO_2
	= –12 128 tonnes CO_2 (rounded to a whole number)

So although carbon stocks have decreased by 12 128 tonnes CO_2, under the liabilities cap, the liability is reduced to 8519 tonnes CO_2.

Example: Change in carbon stocks in a post-1989 forest stand over a period where part of a CAA is harvested and replanted

A post-1989 forest owner who has joined the ETS originally had 45.83 hectares of *Pinus radiata* in Northland planted in June 1996, and filed their first emissions return for the period up to and including 31 December 2012. The forest owner's records show the opening and closing forest carbon stocks for the 2008–2012 reporting period were 11 404.2 and 19 923.0 tonnes CO_2, respectively, and their New Zealand Emissions Unit Register (NZEUR) holding account shows that 8 519 NZUs have been issued.

In June 2014, it was decided to harvest 21.0 hectares of the *Pinus radiata*, and replant this area in *Eucalyptus nitens* in August of the same year. It is now January 2018, and an emissions return is due for the period 1 January 2013 to 31 December 2017. Assume the entire forest area is within one CAA.

For the purposes of this calculation, the *Pinus radiata* forest is considered to be 17 years old at the start of the emissions return period, 18 years old when part of it is harvested and 22 years old at the end of the period. The Eucalyptus nitens forest is four years old at the end of this period. Harvest residues from the *Pinus radiata* forest are also considered to have been decaying for four years, at the end of the period.

The carbon stock at the end of the period, 31 December 2017 is calculated as the sum of the carbon stocks in:

(i) the 24.83 hectares of *Pinus radiata* still standing;
(ii) the carbon stocks in the decaying harvest residues from the 21.0 hectares of *Pinus radiata* forest harvested in 2014,
(iii) the 21.0 hectares of newly planted *Eucalyptus nitens*.

First, calculate the carbon stock in the remaining *Pinus radiata*:
A (the area) = 24.8 hectares
C (carbon stock from the default table at age 22) = 620
T_1 (the total carbon stock) = 24.8 x 620 = 15 376 tonnes CO_2

Second, calculate the carbon stock in the newly planted Eucalyptus nitens forest. Eucalyptus nitens is classed as an exotic hardwood. The appropriate carbon default table values are taken from Appendix 2 (Table 2, column 4 in Schedule 6):
A (the area) = 21.0 hectares
C (the default table) = 34 tonnes per hectare
T_1 (the total carbon stock) = 21.0 x 34 = 714.0 tonnes CO_2

Third, calculate the carbon remaining in the harvest residues from the Pinus radiata forest four years after harvest. The appropriate carbon stock default table values are taken from Appendix 2, Table 3, column 2 in Schedule 6:

A (the area) = 21.0 hectares
C (the default table) = 227 tonnes CO2 per hectare
Tsc (number of years since the trees were cleared) = 4 years (2018 – 2014)
T_2 (the total carbon stock) = A x C x (10-Tsc)/10
= 21.0 x 227 x (10 - 4)) / 10
= 2 860.2 tonnes CO_2

Hence, the total carbon stock at the end of the period is the sum of the carbon stock in the Pinus radiata still standing, decaying harvest residues and the carbon stock in the newly planted trees:
Total carbon stock = 15 376.0 + 714.0 +2 860.2 = 18 950.2 tonnes CO_2
Carbon stock change = 18 950.2 – 19 923.0 = –973 tonnes CO_2 (rounded to a whole number)

The net carbon stock change in the CAA over the period is negative, as the emissions from harvesting the Pinus radiata forest exceed the removals in growing trees over the period. The emissions return for the 2013-2017 period will therefore show that 973 NZUs must be surrendered.

7. Removing post-1989 forest land from the ETS

Participants who wish to withdraw all or some of their CAAs from the ETS, or if all or some CAAs are no longer eligible (e.g. they have been deforested), must notify MPI on the relevant form[14] and surrender the unit balances of the CAAs[15].

Participants who wish to remove land from a CAA follow the same process, but only surrender that part of the CAA's unit balance that relates to the area being removed. The following example illustrates how to calculate the number of units to be surrendered:

Example: Calculating the units to surrender when land is removed from a CAA

In 2016, a participant wishes to remove 25.0 hectares from CAA1 that has a total area of 50.0 hectares, leaving 25.0 hectares remaining. Voluntary emissions return were submitted for the years 2013 and 2014 and CAA1 now has a unit balance of 1 500 units.

Step 1: an emissions return is prepared for CAA1 in the same manner as the mandatory return prepared at the end of each five-year emissions return period, but ending on the date that the land is removed from the CAA. This return shows that the participant is entitled to a further 100 units for CAA1.

Step 2: a notional unit balance of 1 600 is recorded for CAA1 calculated by taking its existing unit balance of 1 500 and adding the entitlement of 100 units determined from Step 1.

Step 3: The unit balance of the land remaining in CAA1 is calculated by apportioning the notional unit balance pro-rata by area as follows:

Unit balance of the land remaining = (1 600/50.0) x 25= 800

Step 4: The number of units that must be surrendered for the 25.0 hectares being removed is calculated as follows:

Net liability to surrender units = $UB_{CAA1} - Ub_r$

where UB_{CAA1} is the unit balance of CAA1 before the removal of the land

UB_r is the unit balance of the land remaining in CAA1

The net liability is therefore 1 500 -800 = 700

14 Available at http://www.mpi.govt.nz/growing-and-producing/forestry/forestry-in-the-emissions-trading-scheme/forms/

15 The process and methodology for this is specified in s191 of the Climate Change Response Act 2002.

8. Glossary

Basal area

Basal area is the cross-sectional area (in square metres) of the stem of a tree measured over-bark at a point that 1.4 metres above the ground level on the uphill side of the tree.

Carbon Accounting Area (CAA)

An area of post-1989 forest land determined by the participant during the ETS registration process that is the basic unit for which accounting of carbon gains and losses is performed. A CAA must be at least one hectare; there are no limits on the number of CAAs a participant may specify; and they do not need to comprise contiguous forest areas.

Carbon Accounting Record (CAR)

A permanent record kept by MPI of the carbon stocks for a CAA, and of the NZUs received or emission units surrendered for that CAA.

Carbon dioxide (CO_2)

A naturally occurring gas, which is also a by-product of burning and breakdown of fossil fuels and biomass, land use changes and other industrial processes. It is the principal human-induced greenhouse gas that contributes to global warming.

Carbon look-up tables

The term carbon look-up tables is used in this guide as a general term to refer to either of the default carbon tables or participant-specific carbon tables – whichever is required to be used by the Regulations.

Carbon stocks

The total carbon in a forest, including that in stem wood, bark, branch, leaves, litter, woody debris, stumps and roots.

Clearing

Clearing includes:

- the felling, harvesting, burning, removing by mechanical means, spraying with herbicide intended to kill the tree, or undertaking any other form of human activity that kills the tree; and
- the felling, burning, killing, uprooting, or destroying by a natural cause or event; but
- does not include pruning or thinning.

Crown conservation contract

Crown conservation contract means a written agreement with the Crown (including a concession granted in accordance with Part 3B of the Conservation Act 1987) for the removal and storage of greenhouse gases on post-1989 forest land that is Crown land managed or administered under the Conservation Act 1987 or any of the Acts listed in Schedule 1 of that Act.

Default carbon tables

The default carbon tables are pre-calculated average values of carbon stocks by forest type, age and, for *Pinus radiata* only, by region. They are provided in the Climate Change (Forestry Sector) Regulations 2008.

Deforestation

Deforest means to convert forest land to non-forest land. A hectare of forest land is treated as deforested if it has been cleared and:

a) 4 years after clearing, the hectare has not:
   i) been replanted with at least 500 stems of forest species; or
   ii) regenerated a cover of at least 500 stems of exotic forest species; or
   iii) been replanted with at least 100 stems of willows or poplars in a manner consistent with managing soil erosion; or

iv) regenerated predominantly indigenous forest species growing in a manner in which the hectare is likely to be forest land 10 years after the hectare was cleared; or

b) 10 years after clearing:
   i) predominantly exotic forest species are growing, but that hectare does not have tree crown cover of at least 30% from trees that have reached 5 metres in height; or
   ii) predominantly indigenous forest species are growing, but that hectare is not forest land; or

c) 20 years after clearing, predominantly indigenous forest species are growing, but that hectare does not have tree crown cover of at least 30% from trees that have reached 5 metres in height.

Deforestation is generally treated as occurring on the date the hectare is cleared as part of the deforestation process. The only exceptions are where deforestation is deemed to have occurred 4, 10 or 20 years after clearance in the circumstances outlined above; however, in these circumstances any liabilities associated with deforestation are calculated as at 4, 10 or 20 years earlier, respectively.

Douglas fir

Means the forest species *Pseudotsuga menziesii*.

Emissions

The release of greenhouse gases into the atmosphere.

Exotic hardwoods

Means exotic forest species in the class *Magnoliopsida* (angiosperms).

Exotic softwoods

Means exotic forest species in the class *Coniferopsida* (gymnosperms), other than *Pinus radiata* or Douglas fir.

Field Measurement Approach (FMA)

The Field Measurement Approach is a field inventory-based method for determining the carbon stocks in participants' registered post-1989 forests. It uses forest growth and carbon models specific to New Zealand's forests for the majority of forest species. Those participants with 100 hectares or more are required to use the FMA.

Forest land

Forest land:

(a) means an area of land of at least 1 hectare that has, or is likely to have, tree crown cover from forest species of more than 30 percent in each hectare; and

(b) includes an area of land that temporarily does not meet the requirements specified in paragraph (a) because of human intervention or natural causes but that is likely to revert to land that meets the requirements specified in paragraph (a);

(c) does not include:

- a shelter belt of forest species, where the tree crown cover at maturity has, or is likely to have, an average width of less than 30 metres; or
- an area of land where the forest species have, or are likely to have, a tree crown cover at maturity of an average width of less than 30 metres, unless the area is contiguous with land that meets the requirements specified in paragraph (a) or (b).

If an area of land temporarily does not meet the forest species and crown cover requirements because of human action or natural events (it may have just been harvested, or trees may have been blown over by strong winds), but is likely to meet these requirements again in the future, it is still considered to be forest land as per paragraph (b) above. Such areas are termed "temporarily unstocked".

Forest species

A tree species capable of reaching at least five metres in height at maturity in the place that it is located, but does not include tree species grown or managed primarily for the production of fruit and nut crops.

For the purposes of the Forestry ETS, any woody vegetation (and including tree ferns) capable of reaching 5 metres in the place it is growing is considered to be a "tree".

Forest type

The forest type of a hectare of forest land can be, based on the predominant single forest species on the land, one of:

- *Pinus radiata*;
- Douglas fir;
- exotic softwoods;
- exotic hardwoods; or
- indigenous forest.

Geospatial mapping information

Information about an area of land provided in the format prescribed in the *Geospatial Mapping Information Standard*.

Harvesting

Harvesting is when the forest species are cleared from the land, and new forest species seedlings are either planted or naturally regenerate. In this case, there is no land use change involved when the trees are harvested. The harvested area remains forest land in a temporarily unstocked state.

Indigenous forest

A forest that comprises tree species that occur naturally in New Zealand or have arrived in New Zealand without human assistance. Strict definitions may relate to the original method of forest establishment (and the direct involvement of people in the process), the mixture of flora and fauna, and the conditions believed to have been present prior to human intervention.

Kyoto Protocol

A protocol to the United Nations Framework Convention on Climate Change that includes emissions limitation or reduction commitments for ratifying countries listed in its Annex B (developed countries and Economies in Transition) (see **http://unfccc.int/resource/docs/convkp/kpeng.html** for further information).

New Zealand Emissions Trading Register (NZEUR)

See **www.eur.govt.nz**.

New Zealand Unit (NZU)

A greenhouse gas emissions unit specific to the New Zealand Emissions Trading Scheme.

Participant

A person becomes a mandatory participant if they undertake certain activities covered by Schedule 3 of the Climate Change Response Act 2002 (for example, deforesting pre-1990 forest land). Other people may become participants by voluntarily registering in respect of activities listed in Schedule 4 of the Act (for example, post-1989 forest land).

Participant-specific carbon tables

Participant-specific carbon look-up tables that show the carbon stock per hectare for an FMA participant's registered post-1989 forest land by forest type and age of trees that are derived from information collected from the participant's forest land. They are used in the same manner as described for the default carbon tables in this guide.

Polygon

For the purposes of mapping, a polygon is defined as a closed shape bounded by sequentially connected polylines that do not cross, such that the map co-ordinates of the end point of one polyline are the same as the map co-ordinates of the start of the next polyline.

Post-1989 forest land

Post-1989 forest land is forest land that:

- was not in forest land on 31 December 1989; or
- was forest land on 31 December 1989 but was deforested (that is, converted to another land use) between 1 January 1990 and 31 December 2007; or
- was pre-1990 forest land, other than exempt land:
  - that was deforested on or after 1 January 2008; and in respect of which any liability to surrender units arising in relation to deforestation has been satisfied; or
  - was exempt land that has been deforested; and in respect of which the number of units that would have been required to be surrendered in relation to deforestation, had the land not been exempt land, have been surrendered.

- was pre-1990 forest land, other than exempt land, that was deforested on or after 1 January 2013 and offset by pre-1990 offsetting forest land; or
- was pre-1990 offsetting forest land that was deforested after 1 January 2013 and in respect of which any liability to surrender units arising in relation to an activity listed in Part 1A of Schedule 3 has been satisfied.

Both exotic and indigenous forest species are eligible to participate in the ETS as post-1989 forest land.

Pre-1990 forest land

Forest land that:
- was forest land on 31 December 1989; and
- remained as forest land on 31 December 2007; and
- where the forest species on the forest land on 31 December 2007 consisted predominantly of exotic forest species.

But does not include any forest land that met the definition above but also:
- has been deforested and any liability arising from that deforestation has been satisfied;
- was declared to be exempt land, has been deforested and the NZUs that would have been required to be surrendered had the land not been exempt, have been surrendered.

Only forests comprising predominately exotic forest species are subject to the ETS as pre-1990 forest land, unless exotic forest species are cleared after 31 December 2007 and in their place indigenous forest species are planted or regenerate on the cleared land.

Predominant forest species

The predominant forest species for an area of forest land is the single forest species with the greatest total basal area.

Regenerate

Means the commencement of growth of seedlings from processes other than planting.

Region

Means a region specified in Schedule 1 of the Climate Change (Forestry Sector) Regulations 2008.

Sequestration

The uptake and storage of carbon. Carbon can be sequestered by plants and soil, and in underground or deep-sea reservoirs.

Sub-area

An area of forest land of at least 1 hectare that:

i) comprises forest species of the same forest type, age and – if the forest type is *Pinus radiata* – the same region.

ii) in relation to determining an area of pre-1990 forest land deforestation, comprises land that is cleared in a single year;

- comprises forest species of the same forest type, age, and – if the forest type is *Pinus radiata* – the same region; and

- where, if the area contains decaying residual wood and roots from previously cleared trees for which emissions must be accounted, that trees comprise forest species of the same forest type, age when cleared, year when cleared, and – if the forest type is *Pinus radiata* – the same region.

Sub-areas may comprise multiple discrete areas of land, and for post-1989 forest land the area(s) comprising a sub-area must be within a single CAA.

Appendix 1: Regions (Schedule 1 of the Regulations)

Auckland means the region encompassing—

a) the areas of land constituted by the Local Government (Auckland Region) Reorganisation Order 1989, Gazette 1989, p 2247 (as in force immediately before 1 January 1990) as—
   i) Auckland City; and
   ii) Franklin District; and
   iii) North Shore City; and
   iv) Manukau City; and
   v) Papakura District; and
   vi) Rodney District; and
   vii) Waitakare City; and

b) the areas of land constituted by the Local Government (Northland Region) Reorganisation Order 1989, Gazette 1989, p 2391 (as in force immediately before 1 January 1990) as—
   i) Far North District; and
   ii) Kaipara District; and
   iii) Whangarei District; and

c) the areas of land constituted by the Local Government (Waikato Region) Reorganisation Order 1989, Gazette 1989, p 2460 (as in force immediately before 1 January 1990) as—
   i) Hauraki District; and
   ii) Thames–Coromandel District

Bay of Plenty means the region encompassing the areas of land constituted by the Local Government (Bay of Plenty Region) Reorganisation Order 1989, Gazette 1989, p 2275 (as in force immediately before 1 January 1990) as—
a) Kawerau District; and
b) Opotiki District; and
c) Rotorua District; and
d) Tauranga District; and
e) Western Bay of Plenty District; and
f) Whakatane District

Canterbury/West Coast means the region encompassing—

a) the areas of land constituted by the Local Government (Canterbury Region) Reorganisation Order 1989, Gazette 1989, p 2296 (as in force immediately before 1 January 1990) as—
   i) Ashburton District; and
   ii) Banks Peninsula District; and
   iii) Christchurch City; and
   iv) Hurunui District; and
   v) Mackenzie District; and
   vi) Selwyn District; and
   vii) Timaru District; and
   viii) Waimakariri District; and
   ix) Waimate District; and

b) the areas of land constituted by the Local Government (West Coast Region) Reorganisation Order 1989, Gazette 1989, p 2517 (as in force immediately before 1 January 1990) as—
   i) Buller District; and
   ii) Grey District; and
   iii) Westland District; and
c) the area of land constituted by the Local Government (Nelson–Marlborough Region) Reorganisation Order 1989, Gazette 1989, p 2375 (as in force immediately before 1 January 1990) as Kaikoura District; and
d) the area of land comprising the Chatham Islands Territory, as defined by section 5 of the Chatham Islands Council Act 1995 (as in force immediately before 1 January 1996)

Gisborne means the area of land constituted by the Local Government (Gisborne Region) Reorganisation Order 1989, Gazette 1989, p 2328 (as in force immediately before 1 January 1990) as Gisborne District

Hawkes Bay/Southern North Island means the region encompassing—

a) the areas of land constituted by the Local Government (Hawkes Bay Region) Reorganisation Order 1989, Gazette 1989, p 2334 (as in force immediately before 1 January 1990) as—
   i) Central Hawkes Bay District; and
   ii) Hastings District; and
   iii) Napier City; and
   iv) Wairoa District; and
b) the areas of land constituted by the Local Government (Manawatu–Wanganui Region) Reorganisation Order 1989, Gazette 1989, p 2351 (as in force immediately before 1 January 1990) as—
   i) Horowhenua District; and
   ii) Manawatu District; and
   iii) Palmerston North City; and
   iv) Rangitikei District; and
   v) Ruapehu District; and
   vi) Tararua District; and
   vii) Wanganui District; and
c) the areas of land constituted by the Local Government (Taranaki Region) Reorganisation Order 1989, Gazette 1989, p 2445 (as in force immediately before 1 January 1990) as—
   i) New Plymouth District; and
   ii) South Taranaki District; and
   iii) Stratford District; and
d) the areas of land constituted by the Local Government (Wellington Region) Reorganisation Order 1989, Gazette 1989, p 2491 (as in force immediately before 1 January 1990) as—
   i) Carterton District; and
   ii) Kapiti Coast District; and
   iii) Lower Hutt City; and
   iv) Masterton District; and
   v) Porirua City; and
   vi) South Wairarapa District; and
   vii) Upper Hutt City; and
   viii) Wellington City

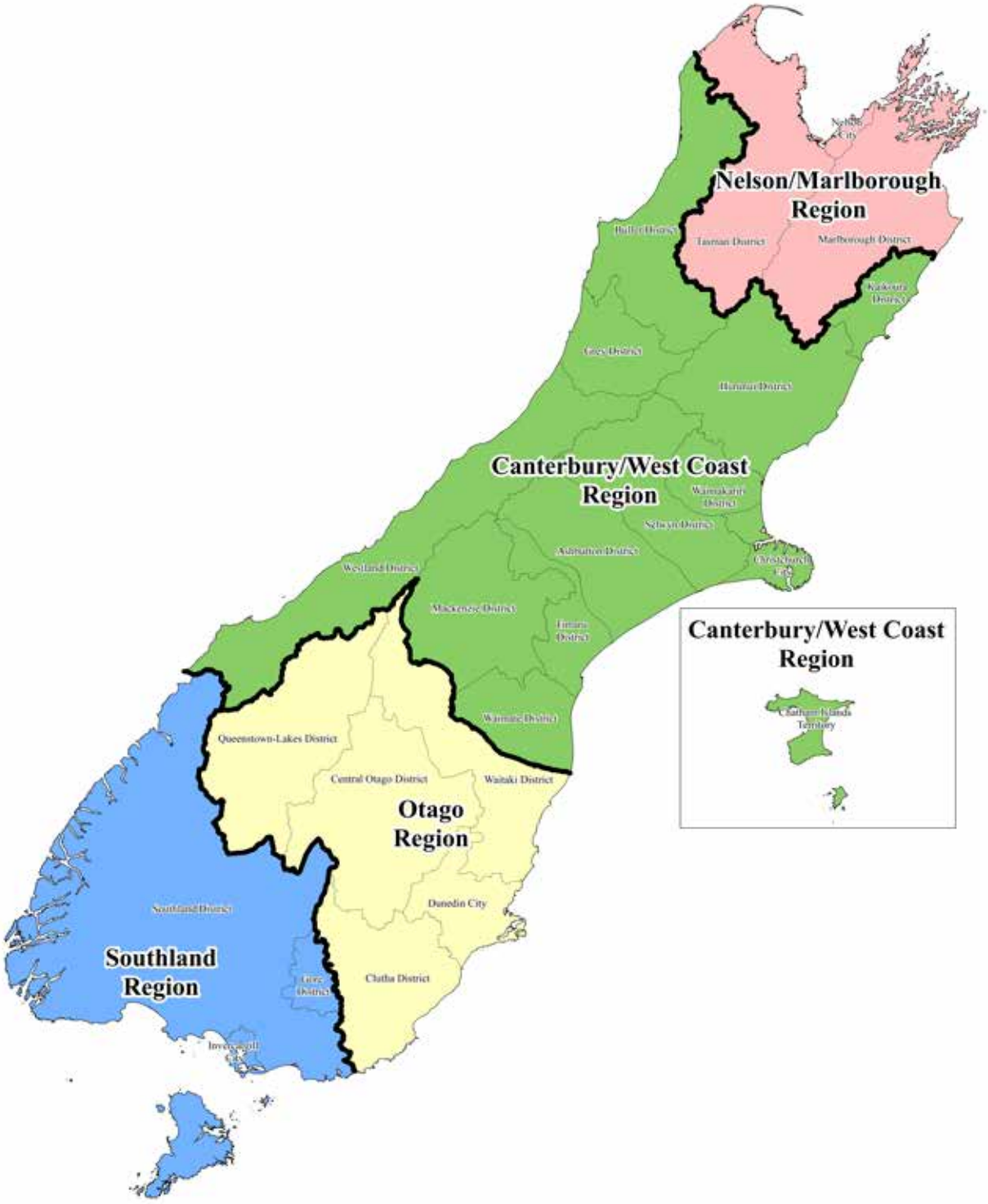
Nelson/Marlborough means the region encompassing the areas of land constituted by the Local Government (Nelson–Marlborough Region) Reorganisation Order 1989, Gazette 1989, p 2375 (as in force immediately before 1 January 1990) as—
a) Marlborough District; and
b) Nelson City; and
c) Tasman District

Otago means the region encompassing the areas of land constituted by the Local Government (Otago Region) Reorganisation Order 1989, Gazette 1989, p 2408 (as in force immediately before 1 January 1990) as—
a) Central Otago District; and
b) Clutha District; and
c) Dunedin City; and
d) Queenstown–Lakes District; and
e) Waitaki District

Southland means the region encompassing the areas of land constituted by the Local Government (Southland Region) Reorganisation Order 1989, Gazette 1989, p 2430 (as in force immediately before 1 January 1990) as—
a) Gore District; and
b) Invercargill District; and
c) Southland District

Waikato/Taupo means the region encompassing the areas of land constituted by the Local Government (Waikato Region) Reorganisation Order 1989, Gazette 1989, p 2460 (as in force immediately before 1 January 1990) as—
a) Hamilton City; and
b) Matamata–Piako District; and
c) Otorohanga District; and
d) South Waikato District; and
e) Taupo District; and
f) Waikato District; and
g) Waipa District; and
h) Waitomo District.

Auckland Region
Far North District
Whangarei District
Kaipara District
Auckland City
Thames-Coromandel District
Hauraki District
Waikato/Taupo Region
Waikato District
Matamata-Piako District
Hamilton City
Waipa District
South Waikato District
Waitomo District
Taupo District
Bay of Plenty Region
Tauranga City
Western Bay of Plenty District
Rotorua District
Kawerau District
Opotiki District
Whakatane District
Gisborne Region
Gisborne District
Wairoa District
Hawkes Bay/Southern North Island Region
New Plymouth District
Ruapehu District
Stratford District
South Taranaki District
Wanganui District
Rangitikei District
Hastings District
Napier City
Central Hawkes Bay District
Manawatu District
Palmerston North City
Tararua District
Horowhenua District
Kapiti Coast District
Masterton District
Porirua City
Upper Hutt City
Carterton District
Wellington City
Lower Hutt City
South Wairarapa District


Nelson/Marlborough Region
Tasman District
Marlborough District
Canterbury/West Coast Region
Westland District
Mackenzie District
Waimate District
Queenstown-Lakes District
Central Otago District
Waitaki District
Otago Region
Dunedin City
Clutha District
Southland Region
Canterbury/West Coast Region
Chatham Islands Territory

Appendix 2: Carbon look-up tables (Schedule 4 and 6 of the Regulations)[1]

Schedule 4: Tables of Carbon Stock per Hectare for Pre-1990 Forest Land

Table 1: Carbon stock per hectare for *Pinus radiata* by region (expressed as tonnes of carbon dioxide per hectare)

Age (yrs)	Ak	W/T	BOP	Gis	H/SNI	N/M	C/W	O	S
9	255	225	233	290	285	187	159	191	237
10	265	235	237	296	286	193	174	200	240
11	283	251	247	308	299	196	182	197	239
12	306	272	263	328	317	206	187	200	248
13	333	296	283	352	341	221	190	210	262
14	363	324	307	380	368	240	198	225	281
15	395	354	334	410	399	262	211	243	304
16	429	385	362	443	431	286	226	265	330
17	463	418	392	476	464	313	244	290	358
18	498	451	423	510	498	341	265	317	389
19	533	485	454	544	532	370	288	346	420
20	568	518	485	578	566	401	312	375	452
21	601	551	515	611	599	431	337	406	484
22	634	584	545	643	631	462	362	437	517
23	666	615	575	674	662	492	388	468	549
24	696	646	603	703	692	522	415	498	581
25	725	676	631	732	721	551	441	529	612
26	753	704	657	760	749	580	467	559	643
27	781	733	683	787	777	609	493	588	673
28	807	761	709	814	804	637	519	618	704
29	834	788	735	840	830	666	546	648	734
30	860	816	760	866	857	694	572	677	764
31	885	842	784	891	882	721	598	706	794
32	909	868	808	916	907	748	623	735	823
33	933	894	831	940	932	775	649	763	852
34	956	919	854	964	956	801	674	791	880
35	979	943	876	988	980	827	699	819	908
36	1 002	968	898	1 011	1 004	852	723	846	936
37	1 024	991	919	1 034	1 028	877	747	873	963
38	1 046	1 015	940	1 057	1 051	901	771	900	991
39	1 068	1 038	961	1 080	1 075	925	794	926	1 018
40	1 090	1 061	981	1 103	1 098	948	817	952	1 044
41	1 111	1 085	1 002	1 126	1 122	972	840	978	1 071
42	1 133	1 107	1 022	1 150	1 145	994	862	1 004	1 097
43	1 155	1 130	1 042	1 173	1 169	1 017	884	1 030	1 124
44	1 176	1 153	1 063	1 197	1 193	1 039	905	1 055	1 150
45	1 198	1 177	1 083	1 221	1 218	1 061	926	1 080	1 176
46	1 221	1 200	1 103	1 245	1 242	1 083	947	1 105	1 203
47	1 243	1 224	1 124	1 270	1 267	1 105	968	1 130	1 229
48	1 266	1 248	1 144	1 295	1 293	1 127	988	1 156	1 256
49	1 289	1 272	1 166	1 321	1 319	1 149	1 008	1 181	1 282
50	1 313	1 297	1 187	1 348	1 346	1 170	1 028	1 206	1 309

Key:
Ak means Auckland
BOP means Bay of Plenty
C/W means Canterbury/West Coast
Gis means Gisborne
H/SNI means Hawkes Bay/Southern North Island
N/M means Nelson/Marlborough
O means Otago
S means Southland
W/T means Waikato/Taupo

1 The information in this Appendix is accurate on the date of publication of this guide but is subject to change if the Regulations are amended, so must not be relied on to prepare and submit any required returns.

Table 2: Carbon stock per hectare for Douglas-fir, exotic softwoods, and exotic hardwoods, and indigenous forest (expressed as tonnes of carbon dioxide per hectare)

Age (yrs)	Douglas-fir	Exotic softwoods	Exotic hardwoods	Indigenous Forest
9	131	137	282	109
10	135	139	310	107
11	143	144	337	108
12	155	151	364	111
13	170	161	390	115
14	187	172	414	121
15	208	185	438	129
16	230	199	460	137
17	254	214	481	146
18	281	229	502	155
19	293	245	522	165
20	308	260	541	175
21	326	276	559	185
22	347	291	576	195
23	370	307	594	205
24	394	321	610	214
25	420	335	626	223
26	446	349	641	232
27	454	363	655	240
28	475	377	668	248
29	500	390	681	255
30	524	403	693	262
31	550	416	705	268
32	576	429	716	274
33	601	442	726	279
34	629	454	735	284
35	654	466	744	289
36	682	478		293
37	706	490		297
38	732	502		300
39	732	513		303
40	753	525		306
41	774	536		309
42	795	548		311
43	816	559		313
44	837	571		315
45	858	582		317
46	878	594		319
47	899	606		320
48	919	617		322
49	938	629		323

Age (yrs)	Douglas-fir	Exotic softwoods	Exotic hardwoods	Indigenous Forest
50	957	642		324
51	976			
52	995			
53	1 013			
54	1 032			
55	1 050			
56	1 068			
57	1 086			
58	1 103			
59	1 121			
60	1 138			
61	1 155			
62	1 171			
63	1 188			
64	1 204			
65	1 220			
66	1 235			
67	1 251			
68	1 266			
69	1 281			
70	1 296			
71	1 310			
72	1 324			
73	1 338			
74	1 352			
75	1 366			
76	1 379			
77	1 392			
78	1 405			
79	1 417			
80	1 430			

Schedule 6: Tables of Carbon Stock per Hectare for Post-1989 Forest Land

Table 1: Carbon stock per hectare for *Pinus radiata* by region (expressed as tonnes of carbon dioxide per hectare)

Age (yrs)	Ak	W/T	BOP	Gis	H/SNI	N/M	C/W	O	S
0	0	0	0	0	0	0	0	0	0
1	0.5	0.4	0.4	0.6	0.5	0.2	0.2	0.3	0.2
2	3	3	2	4	3	1	1	2	1
3	8	7	6	10	9	3	2	5	3
4	29	25	24	37	34	12	5	9	14
5	59	50	51	77	71	28	15	26	35
6	98	84	84	121	113	48	31	49	65
7	131	111	118	162	155	73	53	72	99
8	153	130	143	190	185	100	76	94	134
9	166	142	155	201	197	117	101	124	160
10	188	163	169	219	210	132	125	141	174
11	217	188	188	242	233	144	139	146	181
12	249	218	212	270	260	161	150	156	198
13	283	249	239	302	291	182	158	172	219
14	320	283	269	336	325	206	170	192	244
15	357	318	300	372	361	232	186	214	272
16	396	354	333	410	398	260	205	240	302
17	435	391	367	447	436	290	226	268	334
18	473	428	401	485	473	322	249	298	367
19	511	464	435	522	510	353	274	329	401
20	549	500	468	558	547	386	300	361	435
21	585	536	501	594	582	418	326	394	470
22	620	570	533	628	617	450	353	426	504
23	653	603	564	661	650	482	380	458	538
24	685	636	593	692	681	513	408	490	571
25	715	666	622	722	712	543	435	521	604
26	745	696	650	751	741	573	461	552	635
27	773	726	677	779	769	603	488	583	667
28	801	755	704	807	797	632	515	613	698
29	828	783	730	834	825	661	542	644	729
30	855	811	755	861	852	690	569	674	760
31	880	838	780	886	878	718	595	703	790
32	905	865	804	912	903	745	621	732	820
33	930	891	828	937	929	772	647	761	849
34	954	916	851	961	953	799	672	789	878
35	977	941	873	985	978	825	697	817	906
36	1 000	965	896	1 009	1 002	850	722	845	934
37	1 022	990	917	1 032	1 026	875	746	872	962
38	1 044	1 013	938	1 055	1 050	900	770	899	989
39	1 066	1 037	959	1 079	1 073	924	793	925	1 016
40	1 088	1 060	980	1 102	1 097	947	816	951	1 043
41	1 110	1 083	1 001	1 125	1 121	971	839	978	1 070
42	1 132	1 106	1 021	1 148	1 144	994	861	1 003	1 097
43	1 154	1 130	1 042	1 172	1 168	1 016	883	1 029	1 123
44	1 176	1 153	1 062	1 196	1 192	1 039	905	1 054	1 149
45	1 198	1 176	1 082	1 220	1 217	1 061	926	1 080	1 176
46	1 220	1 199	1 103	1 244	1 242	1 083	947	1 105	1 202
47	1 243	1 223	1 123	1 269	1 267	1 105	967	1 130	1 229
48	1 266	1 247	1 144	1 295	1 292	1 126	988	1 155	1 255
49	1 289	1 272	1 165	1 321	1 319	1 148	1 008	1 181	1 282
50	1 313	1 296	1 187	1 347	1 345	1 170	1 028	1 206	1 309

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Table 2: Carbon stock per hectare for Douglas-fir, exotic softwoods, exotic hardwoods and indigenous forest (expressed as tonnes of carbon dioxide per hectare)

Age (yrs)	Douglas-fir	Exotic softwoods	Exotic hardwoods	Indigenous forest
0	0	0	0	0
1	0.1	0.2	0.1	0.6
2	0.1	1	3	1.2
3	0.4	3	13	2.5
4	1	12	34	4.6
5	2	26	63	7.8
6	4	45	98	12.1
7	7	63	137	17.5
8	20	77	176	24.0
9	33	87	214	31.6
10	50	95	251	40.2
11	69	106	286	49.8
12	90	118	320	60.3
13	113	132	351	71.5
14	138	147	381	83.3
15	165	163	409	95.5
16	193	180	435	108.1
17	222	197	459	120.8
18	253	214	483	133.6
19	268	232	505	146.3
20	286	249	526	158.7
21	307	266	546	170.9
22	331	283	565	182.6
23	355	299	584	193.9
24	382	315	601	204.7
25	409	330	618	215.0
26	436	344	633	224.6
27	445	359	648	233.7
28	468	373	661	242.2
29	493	387	674	250.1
30	518	400	685	257.5
31	545	414	696	264.3
32	572	427	706	270.6
33	597	440	714	276.3
34	625	452	722	281.6
35	650	465	729	286.5
36	679	477		290.9
37	704	489		295.0
38	730	501		298.7
39	730	512		302.0
40	751	524		305.1
41	772	536		307.8
42	794	547		310.4
43	815	559		312.6
44	836	570		314.7
45	857	582		316.5
46	878	593		318.2
47	898	605		319.7
48	918	617		321.1
49	938	629		322.3
50	957	641		323.4

Table 3: Carbon stock per hectare in above-ground residual wood and below-ground roots from cleared *Pinus radiata* by region (expressed as tonnes of carbon dioxide per hectare)

Age (yrs)	Ak	W/T	BOP	Gis	H/SNI	N/M	C/W	O	S
1	0.5	0.4	0.4	0.6	0.5	0.2	0.2	0.3	0.2
2	3	3	2	4	3	1	1	2	1
3	8	7	6	10	9	3	2	5	3
4	29	25	24	37	34	12	5	9	14
5	48	44	43	55	52	28	15	26	35
6	69	61	61	81	77	43	31	43	50
7	92	82	82	108	104	57	44	57	68
8	113	99	103	134	130	71	56	72	88
9	128	112	121	155	150	89	71	84	111
10	133	117	131	165	160	100	85	105	130
11	140	124	134	167	163	112	101	119	141
12	150	133	139	173	168	115	112	124	142
13	161	143	146	180	175	120	123	124	145
14	173	155	155	190	185	126	122	128	151
15	186	167	164	201	195	134	125	133	158
16	199	180	175	212	207	143	128	141	167
17	213	193	186	224	219	153	134	149	177
18	227	206	198	237	232	164	140	159	187
19	241	220	210	249	244	175	147	169	199
20	254	233	222	262	257	187	156	180	211
21	268	246	233	274	269	199	164	191	223
22	281	259	245	287	282	210	174	202	235
23	293	272	257	298	293	222	183	214	248
24	305	284	268	310	305	234	193	226	260
25	317	296	278	321	316	245	203	237	272
26	328	308	289	331	327	257	213	249	284
27	339	319	299	342	337	268	223	260	296
28	350	331	310	352	348	280	233	272	308
29	360	342	320	363	358	291	243	283	319
30	371	353	330	373	369	302	253	295	331
31	382	365	340	384	379	314	264	307	344
32	392	376	351	394	390	326	276	319	356
33	403	387	361	405	401	338	287	332	369
34	413	398	371	415	411	349	298	343	381
35	423	409	380	425	421	361	308	355	393
36	433	420	390	435	431	372	319	367	405
37	443	430	399	445	441	383	330	379	417
38	452	441	409	455	452	393	340	390	429
39	462	451	418	465	462	404	351	402	440
40	471	461	427	475	472	414	361	413	452
41	481	472	436	485	482	425	371	424	464
42	491	482	445	495	492	435	381	436	475
43	500	492	454	505	503	445	391	447	487
44	510	502	463	516	513	455	401	458	498
45	520	513	472	526	524	465	410	469	510
46	530	523	481	537	535	475	420	480	521
47	540	534	491	548	546	485	429	491	533
48	550	545	500	559	557	495	438	502	545
49	561	556	510	571	568	504	447	513	557
50	571	567	519	583	580	514	457	525	569

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Table 4: Carbon stock per hectare in above-ground residual wood and below-ground roots from cleared Douglas-fir, exotic softwoods, exotic hardwoods, and indigenous forest

(expressed as tonnes of carbon dioxide per hectare)

Age (yrs)	Douglas-fir	Exotic softwoods	Exotic hardwoods	Indigenous forest
0	0	0	0	0.0
1	0.1	0.2	0.1	0.6
2	0.1	1	3	1.2
3	0.4	3	13	2.5
4	1	12	34	4.6
5	2	26	48	8
6	4	41	64	12
7	7	52	83	18
8	20	64	101	24
9	31	73	119	30
10	39	80	136	31
11	48	83	152	35
12	57	86	166	38
13	67	90	178	42
14	77	94	190	46
15	89	99	200	52
16	100	104	210	56
17	112	110	219	61
18	125	116	227	66
19	159	122	234	87
20	169	128	242	94
21	187	134	248	104
22	194	140	255	107
23	200	146	262	109
24	208	152	268	111
25	216	157	274	114
26	225	163	280	116
27	233	168	285	122
28	239	174	290	124
29	247	179	295	125
30	255	184	299	127
31	265	190	303	129
32	274	196	307	130
33	283	202	311	131
34	294	208	314	132
35	303	213	317	134
36	315	219		135
37	324	224		136
38	335	230		137
39	342	235		141
40	350	240		142
41	357	246		142
42	365	251		143
43	373	256		143
44	381	262		143
45	389	267		144
46	397	273		144
47	405	278		144
48	413	284		144
49	421	289		145
50	429	295		145