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9(2)(a) [redacted]

9(2)(a) [redacted]

Dear 9(2)(a) [redacted]

Thank you for your email of 18 August 2020 requesting the following under the Official Information Act 1982 (the Act):

> *Would you please forward me a copy of the following publication:*
>
> *Beets, P.N.; Kimberly, M.O.; Goulding, C.J.; Garrett, L.G.; Oliver, G.R.; Paul, T.S.H. 2009: Natural forest plot data analysis: carbon stock analyses and remeasurement strategy. Available on request from the Ministry for the Environment. 136p.*

The Ministry for the Environment has identified one document in scope of your request, as listed in the attached table.

Please note that due to the public interest in our work the Ministry for the Environment publishes responses to requests for official information on our OIA responses page shortly after the response has been sent. If you have any queries about this, please feel free to contact our Executive Relations team: ministerials@mfe.govt.nz.

Yours sincerely

Nigel Searles
Manager, Climate Change

Document schedule

Document no.	Document date	Content	Decisions	OIA sections applied
1	2009	Beets, P.N.; Kimberly, M.O.; Goulding, C.J.; Garrett, L.G.; Oliver, G.R.; Paul, T.S.H. 2009: Natural forest plot data analysis: carbon stock analyses and remeasurement strategy.	Released in full	N/A

Natural forest plot data analysis: Carbon stock analyses and re-measurement strategy

Beets, P.N., Kimberley, M.O., Goulding, C.J., Garrett, L. G., Oliver, G.R., Paul, T. S.H.

May 2009

Natural forest plot data analysis: Carbon stock analyses and re-measurement strategy

Beets, P.N., Kimberley, M.O., Goulding, C.J., Garrett, L. G., Oliver, G.R., Paul, T.S.H.

Date: May 2009
Client: Ministry for the Environment
Client Report No: 42782
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EXECUTIVE SUMMARY

The inventory of New Zealand's natural forest and shrubland from 2002-2007 has shown that:

1. Indigenous forest was a carbon sink between 1990 and 2004, increasing significantly over the 14 year period by 54.6 (±16.2) million tonnes (Mt) based on the total carbon stock in the above ground live biomass and dead coarse woody debris pools,.
2. Since 1990, the coarse woody debris pool increased significantly, however the aboveground live biomass carbon stock in indigenous forest has not changed significantly.
3. The stock change estimates exclude shrubland, because currently only a small sample of the LUCAS forest plots have been remeasured.
4. The total carbon stock in live plus dead organic matter pools is 1,539 (±56 at 95% CI) Mt in the indigenous forest and shrubland class of Land Cover Database 1 (LCDB1), of which:
    a. 989 (±37) Mt is in above ground biomass,
    b. 247 (±9) Mt is in below ground biomass,
    c. 132 (±8) Mt is in coarse woody debris, and
    d. 171 (±29) Mt is in fine debris.
5. The total carbon stock in the indigenous forest and shrubland of LCDB1 includes:
    a. 1,380 (±51) Mt in indigenous forest,
    b. 138 (±20) Mt in shrubland, and
    c. 21 (±11) Mt in planted forest that had been mapped as indigenous forest and shrubland.
6. Since 1990 above ground biomass carbon and stem volume stocks remained largely unchanged or increased in some species, but declined in several other important species. Species that increased over the period included tree species that would have been recovering from past logging activities. Species that declined were considered to be susceptible to possum browsing.
7. The second LUCAS measurement between 2009 and 2013 of all plots in indigenous forest and shrubland should proceed as planned and budgeted, including a proportion (perhaps 5%) of the plots re-measured in a QA/QC process.
8. As plot data are produced, error checking, verification and carbon analysis should proceed without waiting for the complete inventory.
9. Long range planning should budget for a third measurement between 2014 and 2023, with the sampling intensity at the national intensity remaining at the current levels, i.e. 1 plot every 8 sq km, but at half the annual rate of plot measurement.

BACKGROUND

A prime reason for establishing a national plot network within our natural forest and shrubland was to provide an unbiased estimate of carbon stocks, and to collect data suitable for determining if New Zealand's natural forests are carbon neutral, or whether they are a carbon source or sink. The development of a systematic network of permanently located sample plots, which was installed as part of the Land Use and Carbon Analysis System (LUCAS) operated by the Ministry for the Environment, was based on an initial design (Goulding et al. 2001) that was tested for indigenous forest and shrubland on a 60 km wide East – West transect across the South Island (Coomes et al., 2002). The development of LUCAS was motivated by the need to meet New Zealand's reporting requirements under the UNFCCC and the Kyoto Protocol, although both carbon and biodiversity information were collected, to achieve wider government sector benefits from the LUCAS project.

An integral part of the design of the LUCAS natural forest plot network was to re-visit previously established National Vegetation Survey (NVS) plots when they met certain operational criteria. The NVS plots were established 20 or more years prior to the start of the LUCAS project. [The LUCAS natural forest plot network was previously known as CMS-IF&S (Carbon Monitoring System for Indigenous Forests and Shrubland).] The intention of incorporating some revisited NVS plots into the LUCAS natural forest plot network was to enable an estimate of the likely direction of any biomass and carbon stock change for these forests, and was considered to be a pre-requisite to making a decision on any plot re-measurement.

Subsequently to Scion being commissioned to undertake the work presented in this report, a decision was made to re-measure the LUCAS natural forest plot network, of which most plots had been installed and measured for the first time during 2002-2007. The first remeasurement cycle of the full LUCAS plot network would act as a quality control, an error correction process, and provide a measurement of change. Our recommendations regarding the plot re-measurement strategy take this decision into consideration.

OBJECTIVE

Purpose of the project was to:

- Determine carbon stocks in New Zealand's natural forests using data collected by the LUCAS project during 2002-2007. Data required for estimating carbon stocks were checked and when necessary corrected. Carbon stocks per ha were estimated for the four Good Practice Guidance (GPG) pools (IPCC 2003) for each of the valid 1256 plots intersecting the mapped indigenous forest and shrubland cover of the New Zealand's Land Cover Database 1 (LCDB1). The GPG pools include: 1) above ground biomass (living stems, branches, foliage), 2) below ground biomass (living roots), 3) coarse woody debris (dead wood > 10 cm in diameter), and 4) fine debris (leaf litter, dead wood < 10cm in diameter). Plot summaries are reported on a per ha basis for various classes of forest and shrubland (including by forest types, island, region, nationally, and by species). In addition, total carbon stocks per class were calculated by multiplying by the relevant class areas.

- Determine whether New Zealand's natural forests are carbon neutral, or a carbon source or sink. Of the 191 NVS plots in the LUCAS database, 166 were used to estimate stocks as at 1990, and annual stock changes over the period from 1990 to 2004. Changes in both live and dead above ground carbon pools were estimated.

- Recommend a plot re-measurement strategy. The benefits from re-measuring plots are described, and a strategy for analysing the new data is suggested.

KEY RESULTS

Analysis of the LUCAS plot data has shown that:

- Statistically robust national estimates of carbon stocks (95% confidence intervals exclude errors due to measurement or calculation of carbon content per plot) in the indigenous forest and shrubland class of the LCDB1 are:
  - 111 (±4) t/ha in above ground biomass,
  - 28 (±1) t/ha in below ground biomass,
  - 15 (±1) t/ha in coarse woody debris,
  - 19 (±3) t/ha in fine debris, with
  - 173 (±6) t/ha overall mean.

  Total carbon stocks are:
  - 989 (±37) Mt in above ground biomass,
  - 247 (±9) Mt in below ground biomass,
  - 132 (±8) Mt in coarse woody debris,
  - 171 (±28) Mt in fine debris, with
  - 1,539 (±55) Mt overall total.

- Carbon stocks in New Zealand's indigenous forest (ie. excluding shrubland and planted forest types) are:
  - 141 (±5) t/ha in above ground biomass,
  - 35 (±1) t/ha in below ground biomass,
  - 19 (±1) t/ha in coarse woody debris,
  - 23 (±4) t/ha in fine debris, with
  - 218 (±8) t/ha overall mean.

  Total carbon stocks are:
  - 892 (±33) Mt in above ground biomass,
  - 223 (±8) Mt in below ground biomass,
  - 119 (±7) Mt in coarse woody debris,
  - 146 (±27) Mt in fine debris, with
  - 1,380 (±50) Mt overall total.

- The annual change in total above ground biomass carbon stocks since 1990 based on 151 remeasured indigenous forest plots is 0.168 (±0.0.36) t/ha/year, which is comprised of:
  - 0.127 (±0.036) t/ha/year from ingrowth,
  - 1.315 (±0.17) t/ha/year from growth of persistent trees, and
  - -1.274 (±0.32) t/ha/year from tree mortality.

  The annual change in coarse woody debris carbon stocks since 1990 is 0.345 (±0.0.23) t/ha/year. The total change in above ground carbon is therefore 0.513 (±0.0.23) t/ha/year. These estimates indicate that the dead coarse woody debris pool increased significantly at approximately twice the rate of the above ground live biomass pool which did not increase significantly.

- The best estimates currently available of New Zealand's indigenous forest carbon stocks are:
  - 140.1 (±7.5) t/ha in above ground biomass carbon in 1990,
  - 153.8 (±7.5) t/ha in total above ground carbon in 1990,
  - 143.1 (±5.6) t/ha in above ground biomass carbon in 2004, and
  - 162.4 (±6.0) t/ha in total above ground carbon in 2004.

The change in carbon stocks over the 14 year period is therefore:

- 3.0 (±4.4) t/ha in above ground biomass carbon, and
- 8.6 (±2.5) t/ha in total above ground carbon.

Over the 14 year period from 1990 to 2004 and taking into account the total area of indigenous forest, carbon stocks increased nationally by:

- 18.8 (±27.8) Mt in above ground biomass carbon pool, and
- 54.6 (±15.9) Mt in total above ground carbon pool.

This indicates that New Zealand's natural forest has been a significant net carbon sink over this period.

- Although New Zealand's Indigenous Forest and Shrubland has been a net carbon sink over all vegetation types during the period from 1990 to 2004, due to an increase in both the live and dead carbon pools, some species differences were evident. Live tree carbon and stem volume stocks remained largely unchanged for some species and increased significantly in others, however tree biomass carbon and stem volume stocks declined in several important species over this period. Although no specific analysis was done, species that increased over the period included tree species recovering from past logging activity and other disturbances. Species that declined were considered to be susceptible to possum browsing, although not all susceptible species showed a decline.

APPLICATION OF RESULTS

- Data quality assurance checks undertaken as part of this study indicated that some errors in carbon stock and change estimates reported here can be expected, although their impact is expected to be relatively minor. Measurement errors were identified as part of the analysis and can be expected to be corrected during the re-measurement of the LUCAS plot network.

- The regression estimates of national carbon stocks and changes in natural forest are based on 151 NVS plots. Not all NVS plots were included in this analysis, because obvious issues with matching trees over time could not be resolved in the time available. Some issues may not be resolvable, given the long re-measurement interval for some plots. Re-measurement of the LUCAS plot network will indicate whether the increase in carbon stocks from 1990 to 2004 continue after 2004, which will be possible once the data are thoroughly checked and measurement errors and omissions (missed trees and woody debris) have been corrected.

- Carbon stocks were estimated for LUCAS shrubland plots, however stock changes were not estimated, because none of the shrubland plots were measured previously as NVS plots. Carbon stock estimates for plots assessed using the continuous shrubland methodology were in some cases found to be biased. In addition, the continuous cover methodology was found to be subjective, particularly in plots where a combination of tree and continuous cover shrub methods had been employed. Stock estimates will be possible following the re-measurement of these plots, however calculations of stock changes based on shrubland plots should be treated with caution until the shrubland methodology has been assessed for possible bias.

RECOMMENDATIONS

- Estimates of CWD carbon stock changes in New Zealand's natural forest can be made in future either by using decay functions applied to trees that die or by re-measuring the CWD volume stocks and recording the decay class. The analysis undertaken in this report suggested that CWD stocks are increasing, presumably because logging has historically impacted on the size of the dead carbon pool. Provided that decay functions are reliable, the CWD pool will not need to be re-measured in future, but can be modelled. The CWD pool is being re-measured in year 1 plots, which is important for data checking purposes.

- The reliability of decay functions could be improved in future by recording the incidence of decay agencies that influence decay rates, in particular of the decay fungus, Ganoderma.

- It is particularly important that LUCAS provides unbiased estimates of carbon stock changes in New Zealand's shrubland vegetation where potentially the largest change in carbon stocks is likely to occur. The methodology for assessing shrubland carbon stocks needs to be carefully assessed for bias. This assessment would ideally be undertaken after the year 1 plots are re-measured, in order to: 1) to check if the carbon stock change estimates are valid, and 2) ensure that data collection protocols and the vegetation manual are revised prior to year 2 plots being re-measured, and 3) to allow time for training of field teams.

- Plot horizontal areas need to be carefully checked for the 20 x 20 m square plot. In addition, in the 20 m horizontal radius circular plot approximately 1 in 4 trees have been missed in the 2002-2007 measurement, biasing estimates of carbon stocks for indigenous forest.

- Data collected by the LUCAS project will be able to achieve wider sector benefits in relation to for example the Emissions Trading Scheme (ETS) if shrubland plots are aged, while ensuring that stock change estimates are valid.

- The second field measurement between 2009 and 2013 of all existing plots, plus new plots in new forests and shrubland or where access is now granted, should proceed as planned and budgeted. At the very least in the first year or two, a proportion (perhaps 5%) of the plots be re-measured independent of the main field measurement in a QA/QC process. As plot data is produced, error checking, verification and carbon analysis should proceed without waiting for the complete inventory.

- Long range planning should budget for a third measurement between 2014 and 2023, with the sampling intensity at the national intensity remaining at the current levels, i.e. 1 plot every 8 sq km, but at half the annual rate of plot measurement.

INTRODUCTION

Carbon stocks in New Zealand's natural forest and shrubland can be estimated using the LUCAS natural forest plot network which was installed on an 8 km grid over a five year period from 2002 – 2007 within areas mapped as natural forest and shrubland by the Land Cover Database 1 (LCDB1). The entire plot network has only been measured once using methods documented in Payton et al. (2004), and Davis et al. (2004). However, 191 National Vegetation Survey (NVS) forest plots which were established 20 - 40 years prior to the start of the LUCAS project, were incorporated and measured as part of the LUCAS plot network to estimate the 1990 baseline, and to provide an indication of whether New Zealand's natural forest is carbon neutral, or a carbon source or sink. Only live trees were measured in NVS plots, while LUCAS aims to provide national estimates of carbon stocks and changes in both live and dead pools. The current report presents carbon stock and change estimates in live and dead carbon pools based on measurement of the LUCAS plot network up to and including 2007. Carbon stocks were estimated from plot data using allometric functions for trees, and shrub biomass samples for shrubs, following Coomes et al. (2002).

Carbon stocks in New Zealand's forest and shrubland reflect carbon in four IPCC Good Practice Guidance pools: 1) above ground biomass in trees > 2.5cm DBH and shrubs (AGB), 2) below ground biomass (BGB), 3) coarse woody debris (CWD), and 4) fine woody debris and litter (FD). Coarse woody debris arises from mortality of trees and branches > 10 cm in diameter, while fine debris arises from litterfall < 10 cm in diameter and mortality of trees < 10 cm in DBH.

Estimates undertaken previously of carbon stocks in the NVS plots within the LUCAS network measured up to and including 2002/2003 revealed no significant change in the above ground live tree carbon pool (Peltzer and Payton (2006). Their analysis did not include changes in the coarse woody debris carbon. More recently, Hall (2008) estimated changes in biomass carbon of New Zealand's natural forest using data from 2796 plots that had been remeasured from 1956 – 1998, and showed that the live tree biomass carbon pool fluctuated over time, depending on forest types and elevation, while the "possum-preferred" species group declined consistently. However, as in the Peltzer and Payton (2006) analysis, changes in the dead carbon pool were not assessed.

Subsequently, a methodology was applied to estimate the change in the coarse woody debris (CWD) carbon stock over time, using recently developed decay functions (Beets et al., 2008a) and allometric equations (Beets et al., 2008b). This methodology was tested using a subset of NVS plots with at least four re-measurements, which provided suitable time series data for estimating above ground carbon of trees at the time when tree mortality likely occurred. These estimates of tree carbon stocks and tree mortality date were coupled with decay functions to estimate the amount of carbon in the CWD pool at the LUCAS measurement date that was contributed by trees that died since 1990. The CWD contributed through tree mortality since 1990 was subtracted from the total CWD stock present at the LUCAS measurement date, and the CWD carbon stock as at1990 derived from by applying the decay functions in reverse (Beets et al., 2008c). The current report incorporates this methodology to provide estimates of carbon stock and change estimates for the full set of LUCAS plots, including both the live and dead carbon pools.

LUCAS includes a total of 1372 plots intersecting the natural forest and shrubland class of LCDB1 on an 8 km grid. The number of vegetation plots installed and measured was 1257, of which 1 plot was not used in this analysis to estimate carbon stocks because it was outside the LCDB1 mapped area (Table 1). Locations of plots for each sampling year are shown in Fig. 1. Where possible, pre-existing NVS plots were incorporated into the network. This occurred at 191 grid locations, although due to data quality issues, the earlier NVS measurements could only be used for only 166 of these plots. These NVS plots were measured progressively from 2002 to 2007 along with the other LUCAS plots as shown in Table 1.

Table 1.

Total number of natural forest and shrubland plots in the LUCAS database (where LUCAS refers to 2002 – 2007 measurement of all plots and NVS refers to plots with earlier data) and the number used for calculation of carbon stocks/ha in forest and shrubland and stock changes in indigenous forests as entered on the database.

Sampling Year	No. of LUCAS plots measured	No. of LUCAS plots used in the analysis	No. of NVS plots measured	No. of NVS plots used in the analysis[A]
2002-03	308	308	40	36
2003-04	332	332	61	54
2004-05	280	279	45	36
2005-06	300	300	44	39
2006-07	37	37	1	1
Total	**1257**	**1256**	**191**	**166**

[A]: Stock changes were based on plots where tree tags matched over time

The locations of the NVS re-measurement plots are shown in Fig. 2. As these plots are intended to provide carbon change estimates within the LUCAS network, their distribution within the indigenous forest and shrubland area is of critical importance. As can be seen from Fig. 2, the NVS plots are fairly widely scattered. However, they do not perfectly represent the population. In the South Island, the NVS plots tend to be located predominantly along the eastern margin of the broad swath of indigenous forest and shrubland running along the western side of the island. In the North Island, NVS plots are well represented within the southern and central regions, but the extensive forested areas in the east and west of the island are very poorly sampled, and there is a complete absence of NVS plots in the northern part of the island. However, as will be explained later in the report, by using regression estimators we believe that reasonable estimates of carbon change at a national level can be obtained from these plots.

The locations of plots identified either as indigenous forest or shrubland, the two broad vegetation types covered by the LUCAS network, are also shown in Fig. 2. In practice, shrubland is often actually regenerating indigenous forest and it is therefore frequently difficult to clearly differentiate between these vegetation types. In this project, all LUCAS plots were classified as indigenous forest or shrubland using EcoSat Forest types (Shephard et al. 2005) rather than on the basis of the original LCDB1 classification.

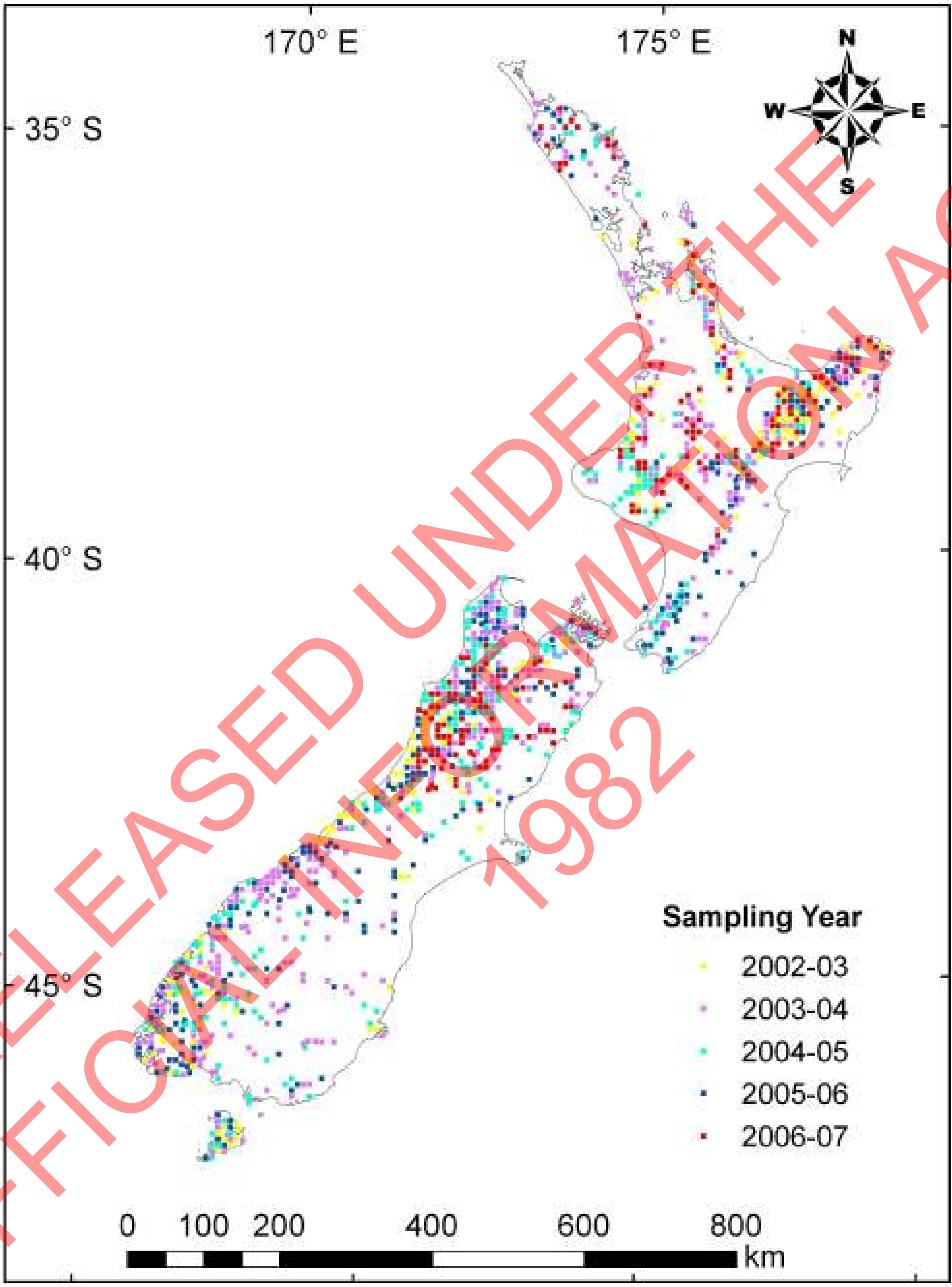

Fig. 1. Location of indigenous forest and shrubland LUCAS plots by measurement year.

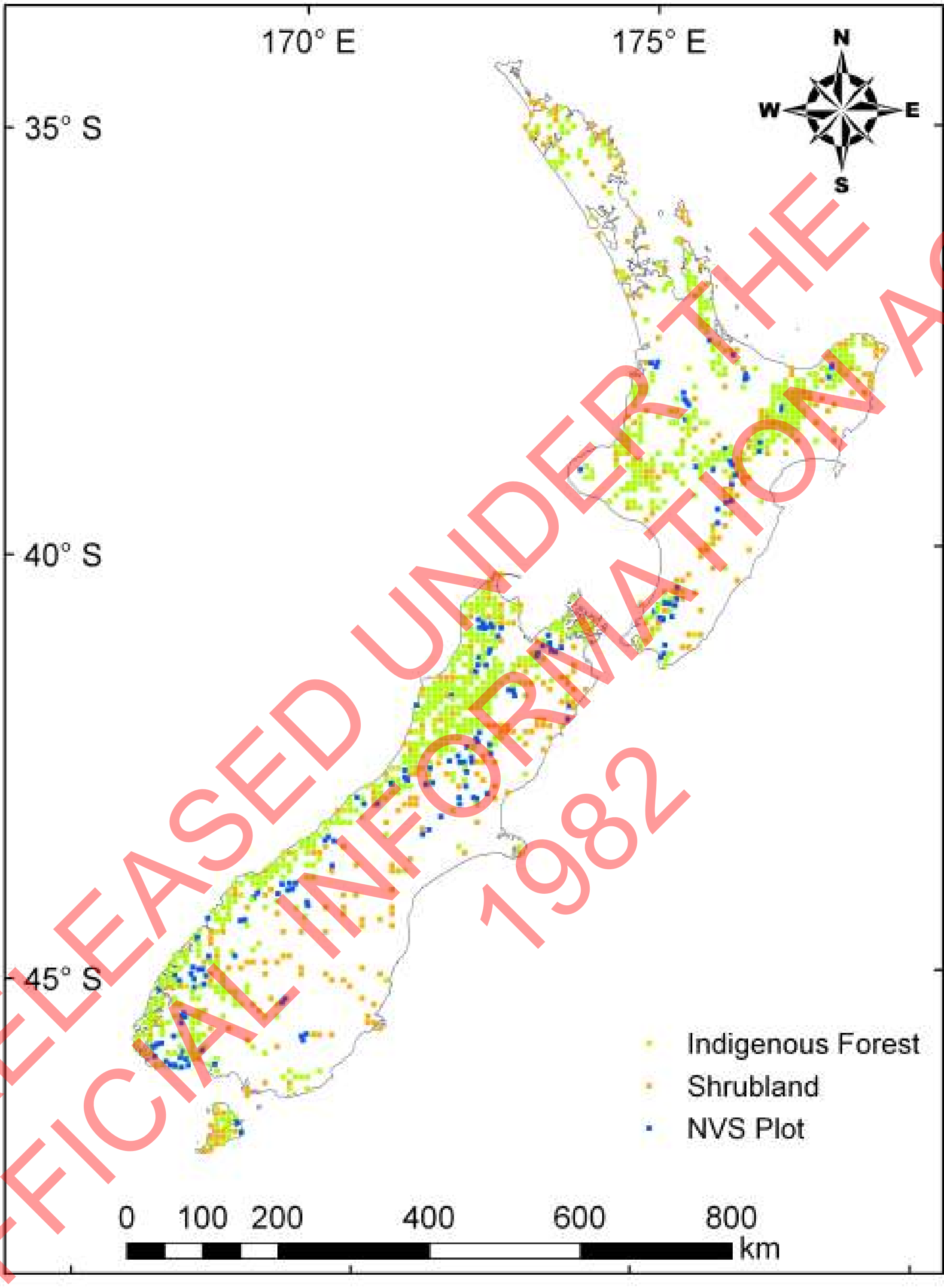

Fig. 2. Location of LUCAS plots classified as indigenous forest or shrubland using EcoSat, and of the 166 NVS remeasurement plots.

Approximately 1/3rd of the vegetation plots were sampled to determine carbon in the dead organic matter and mineral soil pools. Litter includes fine woody debris less than 10 cm in diameter (FWD), and the litter (L), fermenting (F) and humus (H) layers. LFH data were obtained from 331 plots and FWD from 190 plots (Table 2). Carbon estimates for mineral and organic soils are not included in this report.

Table 2.
Total number of soil plots sampled to assess FWD, L, FH(O), and mineral soil (including organic soil) carbon stocks.

Sampling Year	FWD	L and FH(O)	Mineral Soil [A]	Plots abandoned
2002-03	30	0	0	99 [B]
2003-04	53	113	113	
2004-05	41	85	85	5 [C]
2005-06	46	113	113	
2006-07	20	20	20	
Total	**190**	**331**	**331**	**104**

[A]: Includes Organic Soils, a total of 18 plots.
[B]: Laboratory data for L, FH(O), and mineral soil for year 2002-03 (99 plots) failed QA. 30 plots retained for FWD.
[C]: No summary sheets for 4 soil plots. AT127 abandoned, no samples collected - under snow.

Prior to undertaking carbon stock and change calculations for this report, the data were extensively checked and corrected, and various data processing issues identified and resolved. Checks performed included that the dimensions of trees and shrubs were within acceptable limits, that tag numbers assigned to a tree were consistent over time for LUCAS plots that were installed originally as NVS plots, that the species name and tree status code (live or dead) were correctly assigned over time, and that growth rates were within acceptable limits. Tree matching over time was essential in order to differentiate between carbon stock changes of trees that persisted as live trees throughout the period of interest, died during the period, or appeared as ingrowth.

MATERIALS AND METHODS

1.1 DATA QUALITY ASSURANCE (QA) METHODS FOR DATA THAT AFFECT CARBON CALCULATIONS

The LUCAS indigenous survey database contains the vegetation plot data for indigenous forest and shrubland vegetation that was used in the analysis described in this report. Relevant data were accessed using a number of tables which contain the variables required for calculating carbon stocks in forest and shrubland plots. The database table names, description, and variables required for carbon calculations are shown in Table 3.

Table 3.
List of tables in the LUCAS database and variable names containing data used to calculate carbon stocks/ha/plot.

LUCAS table name	Description	Variables used for C calculations
t527_StemDiamHt	Breast height diameter at 1.35 m height of trees ≥2.5 cm and total height of trees in forest and shrubland plots	StemDiamHtID, SurveyID, CMSID, Subplot, Species code, Tag, DBH, Height, Stem status, Lean angle, Decay class
t525_CWDPieces	Dimensions of coarse woody debris ≥10cm diameter in forest and shrubland plots	CWDPieceID, CMSID, Subplot, Species code, Decay class, Length, LED1, LED2, SED1, SED2
t538_ShrubDiscrete	Dimensions of discrete shrubs >30 cm in height	ShrubDiscreteID, CMSID, SubPlot, Species code, Width1, Width2, Height
t541_ShrubsContinuous	Shrub (quadrant) heights of shrubs >30 cm in continuous cover shrub plots and in continuous biomass harvest subplots	ShrubContinuousID, CMSID, PlotType, Quadrant, Height
t543_ShrubLayout	Area occupied by continuous shrub cover >30 cm ht. in shrubland plots	ShrubLayoutID, CMSID, Subplot, X1, X2, X3, Shape
t539_ShrubBiomassHarvest	Above ground biomass harvest data for discrete and continuous shrubs cut at ground level	ShrubBiomassHarvestID, CMSID, SampleNo, Methodology, Species code, Width1, Width2, Height, DryWeight_Total.
t540_ShrubContinous Biomasslayout	Biomass harvest subplot horizontal area information for continuous cover shrubland plots	ShrubContinousBiomasslayoutID, CMSID, LongAxis1_TapeDist, LongAxis1_Slope, LongAxis2_TapeDist, LongAxis2_Slope, ShortAxis1_TapeDist, ShortAxis1_Slope, ShortAxis2_TapeDist, ShortAxis2_Slope
t521_IFLayout	Plot horizontal area information for indigenous forest and shrubland plots	IFLayoutID, CMSID, Line, Tape distance, Slope, Horizontal distance
t510_PlotAbandoned	LCDB1 mapped versus observed	PlotAbandoned

The soil data from the indigenous survey has yet to be uploaded onto the LUCAS database. Data were received from MfE in excel format for all Litter data called 'original data'. On file at Scion were FWD and PlotSlopeArea, and additional slope data for 171 plots which were entered from original field sheets or PDF files.

The original data contained litter laboratory data for all plots (ie, C%, N%, Fine Earth weight (g)) and relevant field data for plots assessed by Landcare Research. Relevant field data collected by Scion were copied from the ICMS_Database[1]. All litter data were entered into one table based on the ICMS_Database table. The database table names, description, and variables required for carbon calculations are shown in Table 4.

Table 4. List of tables and variable names containing data used to calculate Litter and FWD carbon stocks/ha/plot.

Table name	Description	Variables used for C calculations
Litter	All field and lab litter data <2.5 cm in diameter	LabID, CMSID, SampleTypeID, Total Bulked Sample, Quarter, C%, Fine Earth & LFH (g), Gravel (g), Quarter No., Quadrat Square No., Total Area (m2).
FWD	All field FWD data, no lab data ≥2.5 < 10 cm in diameter	CMSID, Quarter, Drywt (g), SampleCollected, Collection Area (m2).
PlotSlopeArea	Measured area over horizontal area – ratio for slope correction conversion	CMSID, Quarter, SlopeName, No Slope, Reason for no slope, SlopeAll, Projected area (m2), t520_Slope, QuarterRatio, PlotRatio3.
t520_Plot reece	Plot reece	CMSID, Slope

1.1.1 Information held in database used for QA purposes

The data collection protocols for vegetation measurement are documented in Payton et al., 2004. In summary, permanent 20 x 20 m plots were installed on the slope, with the tape length and slope angle of each plot side measured in one or more steps, depending on visibility in relation to the density of understory vegetation and changes in topography between the corner peg markers, for calculating the plot horizontal area. In addition, the horizontal length of each side of the plot was similarly measured in one or more steps using a Vertex, thus giving two independent measures of the plot horizontal area. In addition, a 20 m horizontal radius plot, centered over the 20 x 20 m square plot, was installed at each site, where large live and dead stems (>60cm DBH) and large CWD were measured. The nested plot design aimed to improve the precision of the total carbon stock estimate by measuring more of the large trees at each site.

Of the total number of plots entered in the LUCAS database (1372 plots), the number installed and measured during 2002-2007 was 1257, of which 1 plot was not used in this analysis to estimate carbon stocks because it was outside the LCDB1 mapped area (Table 1). Plots were not installed at 115 sites because either permission could not be

[1] Garrett, L.G., Oliver, G.R. and Beets, P.N. 2008. ICMS Database – FWD and Litter C Content. Report for the Ministry for the Environment, Scion Research, pp 11.

obtained from land owners, or because of safety considerations owing to the steep topography.

Of the 191 NVS plots, 166 (86%) were suitable for stock change calculations. The remaining 25 NVS plots were not suitable because tree numbering issues could not be adequately resolved in the time available to undertake this analysis. Several of the 166 plots were not used in carbon stock change calculations either because the plot measurement date was less than 10 years from the most recent measurement date, or because the plot was mapped as shrubland. While 151 plots were used in developing regression relationships for estimating live and dead carbon pools, the 142 plots mapped as indigenous forest were used to adjust carbon stocks in the 889 EcoSat mapped forest plots (excluding planted plots) to 1990, which is the baseline year. The 142 NVS plots had a mean measurement year of 1983, and ranged from 1976 – 1995. Given that the mean measurement year for the LUCAS measurement of these NVS plots was 2004, the stock change estimates reflect changes over the preceding 21 years.

Live and dead tree and coarse woody debris measurements

Within the 20 x 20 m inner plot, all live stems with a DBH ≥2.5 cm were individually tagged and the DBH of all stems and a sample of tree heights (Ht) measured and recorded by species. Stem status (live or dead) was noted, and height and decay class were recorded for each standing dead stem greater than 10 cm in DBH. If the lean angle exceeded 20 degrees then the lean angle was measured and recorded along with the apparent height. For stems snapped off at less than 1.35 m in height (coded as "S"), nominally the large end diameter (sometimes as orthogonal diameters) and stump height were measured and recorded as coarse woody debris by species if possible, or classified as unknown. Fallen dead stems ≥10 cm in diameter were also measured as coarse woody debris and coded as "F", with orthogonal widths at both the large and small end of what should have been more-or-less uniformly tapering stem sections, and stem section length measured and recorded by species if possible, or classified as unknown. In addition, live and dead stems greater than 60 cm DBH and all heights and CWD great than 60 cm small end diameter were measured in the 20 m horizontal radius plot.

When existing NVS plots were incorporated (191 plots) in the network, this facilitated more precise checking of the 20 x 20 m plot data for carbon stock and change calculation purposes. Historical stem DBH of trees ≥2.5 cm and status (live or dead) information had been acquired for NVS plots. With such historical data, categorization of stems in terms of recruitment (ingrowth), growth, and mortality is possible, provided that individual trees can be matched over time. Matching also helped to identify issues such as missing DBH measurement, unusual growth trends, ingrowth, tree mortality, duplicate records, and plots that for various reasons could not be matched.

Shrub measurements

Shrubland vegetation was measured using either the discrete (orthogonal widths and height) or continuous shrub assessment methodology. For each main plot, the area of subplots occupied by continuous shrubs was assessed, and for discrete subplots the dimensions of individual discrete shrub were measured. Shrub height of subplots with continuous shrubland was measured at the corners of each subplot (quadrant heights).

Above ground biomass harvest data were collected adjacent to the main plot, including of individual discrete shrubs and of continuous shrubland subplots of known dimensions. For discrete shrubs, the dimensions and total fresh weight of each shrub and, if too large to carry out, the fresh weight of a sample were recorded along with the total or sample dry weight of the shrub after being dried to constant weight in a forced ventilation oven at 70 degrees C. The fresh weight of shrubs in unit area harvest subplots (usually a mixture of species) were likewise weighed in total, and a representative sample weighed if necessary, and the total or sample material oven dried and weighed. Biomass subplots were assumed to be installed in areas occupied by continuous (100%) shrubland, because harvested plots were meant to represent the area occupied by continuous cover shrubs in subplots within the main plot.

Given the large number of plot sheets and associated data tables involved in this study, a check was also made to ensure that all data required for undertaking the carbon stock and change calculations were entered in the database and that superfluous data were identified and excluded from the calculations. This check tended to be an iterative process, with missing data only becoming evident after various pieces of information were drawn together for calculation purposes.

It should also be noted that measurement units for recording data on field forms in some instances changed following the revision of the manual in 2004. A check was therefore made to see if data entry personnel were able to consistently accommodate such changes. We noted that old field forms were still sometimes being used after the revised manual had been issued, further complicating the task of data entry. In addition, the shrub biomass harvest field forms had sometimes been electronically altered, and were therefore not consistent with the revised manual –further complicating both field recording and data entry.

Forest floor measurements
The data collection protocols for forest floor and soil measurement are documented in Davis et al. (2004). In summary, fine woody debris (FWD), litter (L), FH(O), and mineral soil (0 – 10, 10 – 20 and 20 – 30 cm) were collected from up to four random points (quarter admp) 2 m outside the 20 x 20 m main plot.

In the case of FWD, L and FH(O), three samples were collected per quarter, giving twelve sample points per plot. The slope was measured at each of the sampling points. Samples were mostly collected using 0.1 m^2 quadrats, but also using cores depending on the FH(O) thickness. Where there were time constrains then either 3, 2, or 1 of the four quarters was sampled.

L and FH(O) samples were each bulked by plot in the laboratory, and total oven dry mass measured and analysed for total carbon (C) concentration (expressed as g C/100 g oven dry matter). Approximately 10% of the plots were measured in the laboratory on an individual quarter basis (quarter admp). Where individual quarters were analysed, the total C and N concentrations were weighted using the total oven dry weights to obtain weighted C and N concentrations on a plot basis, identified as 'bulked' in Lab ID' variable.

FWD samples were collected and weighed on an individual quarter basis, with no C or N analysis undertaken. Therefore, in the case of FWD half the oven dry mass was assumed to be carbon (Rowell, 1984).

A total of 331 plots have laboratory data for LFH(O) and a total 190 plots have FWD data (Table 2) for calculating the firest floor C stock, as described in Section 2.1.14.

1.1.2 Data checking and correction approach

A copy of the LUCAS database was installed at Scion and this version was modified as described. Only the variables of interest in the database (see Table 3) were checked, table by table, as described in Appendix 1. Data entry errors, identified after referring to plot PDF files, were corrected in Scion's copy of the LUCAS database. This included adding records to the database that had been missed during data entry. Errors of measurement that could not be resolved were left uncorrected in the database. These records were filtered out for either one or both (as indicated below) of the carbon stock and change calculations using SAS.

The FWD, L and FH(O) data were checked using the plot PDF files, as described in Garrett (2009). Only the variables of interest for the calculation of carbon content were checked. Corrections to the data and decisions made with respect to calculating carbon stocks in FWD, L, FH(O) data are documented in Garrett (2009) and summarised in Appendix 1.

2.1 CARBON STOCK ESTIMATION METHODOLOGY FOR FOREST AND SHRUBLAND PLOTS

This section documents the methodology used to estimate carbon stocks per plot (Appendix 2) in four of the five GPG carbon pools: 1) above ground biomass (AGB), 2) below ground biomass (BGB), 3) coarse wood debris (CWD), and 4) fine woody debris and L/F/H horizons (FD), excluding mineral soil carbon to 30 cm depth, for plots located in New Zealand's natural forest and shrubland. Carbon stocks were reported by island and nationally, and also by forest type, species, conifer versus broadleaf species, and other data groupings.

2.1.1 General approach

The methodology for above ground biomass carbon of trees utilizes existing allometric functions derived from biomass studies (Beets et al. 2008b) that were applied to tree DBH and height measurements, or height estimates for trees without a height measurement, coupled with whole stem wood density estimates tabulated by species if possible, or species groupings (Appendix 3).

Shrubland plots were measured using a combination of methods, and therefore several different calculation procedures were required. Biomass carbon in large (≥2.5 cm DBH) shrubs measured as trees was estimated as described for trees. Biomass carbon in other shrubs measured using the discrete shrub method was calculated from the orthogonal widths and height of each individual shrub, and species specific crown density estimates developed using the discrete shrub biomass data. Biomass carbon in continuous shrubland, excluding trees, was calculated using the continuous shrub area and quadrant height data for each subplot, and the plot specific canopy density estimate developed using the continuous shrub unit area biomass data. Within a subplot of shrubs only one shrub method was used. Carbon was assumed to comprise 50% of the dry weight data.

The carbon stock in below ground biomass was assumed to comprise 25% of the carbon in above ground biomass. This factor was applied both to trees and shrubs. Fallen CWD carbon stocks were calculated from the debris volume, which was estimated from the large and small end diameter and length measurements, while standing CWD volume was estimated from DBH, (truncated) spar height, and a taper function, and wood density tabulated by major species type, modified using decay class specific wood density modifiers, or if species was unknown, using a decay class specific modifier averaged across all species (Appendix 5).

Carbon stocks in fine debris and litter was estimated from unit area harvest samples collected from approximately 1/3rd of the plots, which were converted to a horizontal area basis by applying slope correction factors.

Tree, shrub, and CWD carbon stocks per plot were expressed on a horizontal unit area basis. Carbon stocks in trees ≥ 60 cm DBH and CWD ≥ 60 cm LED were assessed within a 20 m horizontal radius circular plot, which was converted to a unit horizontal area. Trees < 60 cm DBH and CWD < 60 cm LED were assessed within a 20 x 20 m square plot installed on the slope, which was converted to a unit horizontal area basis taking into account the horizontal area estimate calculated from horizontal distance measurements obtain along the four plot axes using a Vertex.

The specific calculation procedures are described in the following sections of the report.

2.1.2 Height model for tree and large shrub stems

The database contains 191,972 live stems. DBH was assessed for all stems but stem height was obtained only for a sample of 39,395 stems. To estimate the carbon content of a stem, it was first necessary to estimate heights of all stems.

The standard procedure for estimating tree heights in forest inventory is to derive a height/diameter model from those stems assessed for both DBH and height, and to use this to predict heights for trees measured only for DBH. A reasonable relationship exists between height and diameter for all tree and shrub species in the LUCAS database (Fig. 3). However, for tree ferns, the height/diameter relationship is very weak, and heights for tree ferns were therefore estimated using a different procedure as described in the following section. Vine species were not included in any of the carbon calculations as they also display no usable height/diameter relationship and form only an insignificant component of the total indigenous forest stem volume and carbon.

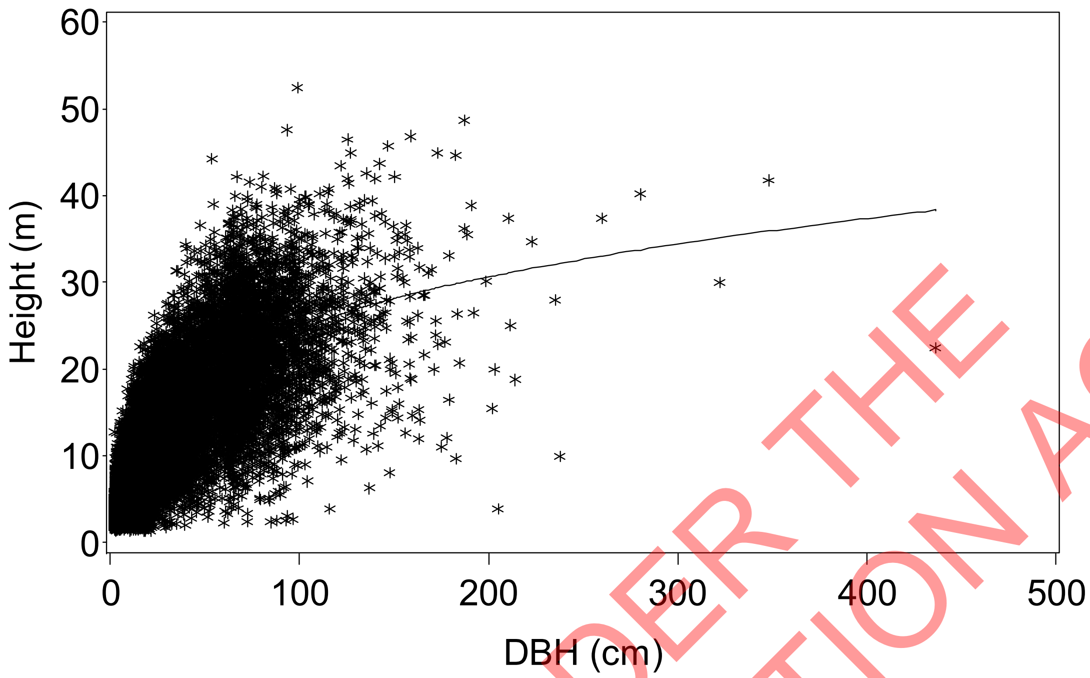

Fig. 3. Relationship between height and DBH of all live, non-leaning stems in the database excluding tree ferns and vines.

Various model forms have been used for relating stem height to DBH. One commonly used function is: $H = 1.35 + \left(a + \frac{b}{D}\right)^c$, where H is height (m) and D is DBH (cm). This equation with c = -2.5 is the model used by Deadman and Goulding (1979) for *Pinus radiata* in New Zealand, and is used in the Scion Permanent Sample Plot (PSP) System. This model was tested, but found not to perform satisfactorily for the indigenous CMS data.

Another commonly used function,

(1) $H = 1.35 + \exp\left(a + bD^c\right)$

was found to perform much better. This model has been used by many authors, often with c set to -1 (eg, Burkhart and Strub, 1974; Burk and Burkhart, 1984; Buford, 1986). Alternatively, c has been estimated from the data or tested over a range of values (Curtis et al. 1981; Larsen and Hann, 1987, Wang and Hann, 1988; Huang et al. 1992; Martin and Flewelling, 1998). For the Indigenous CMS data, a range of values for c were tested. Note that this function can be converted into a linear form, i.e., $\ln(H - 1.35) = a + bD^c$. Ideally, the value of c which best achieves a linear relationship between log-transformed height and D^c should be chosen. In practice, any value for c between -0.4 and -0.2 was found to perform satisfactorily. This model with c = -0.3 was chosen as it performed satisfactorily for all tree and shrub species in the database. Fig. 4 displays the linearized form of the model for the data while Figs. 5-8 show the relationship for two common tree species and two shrub species.

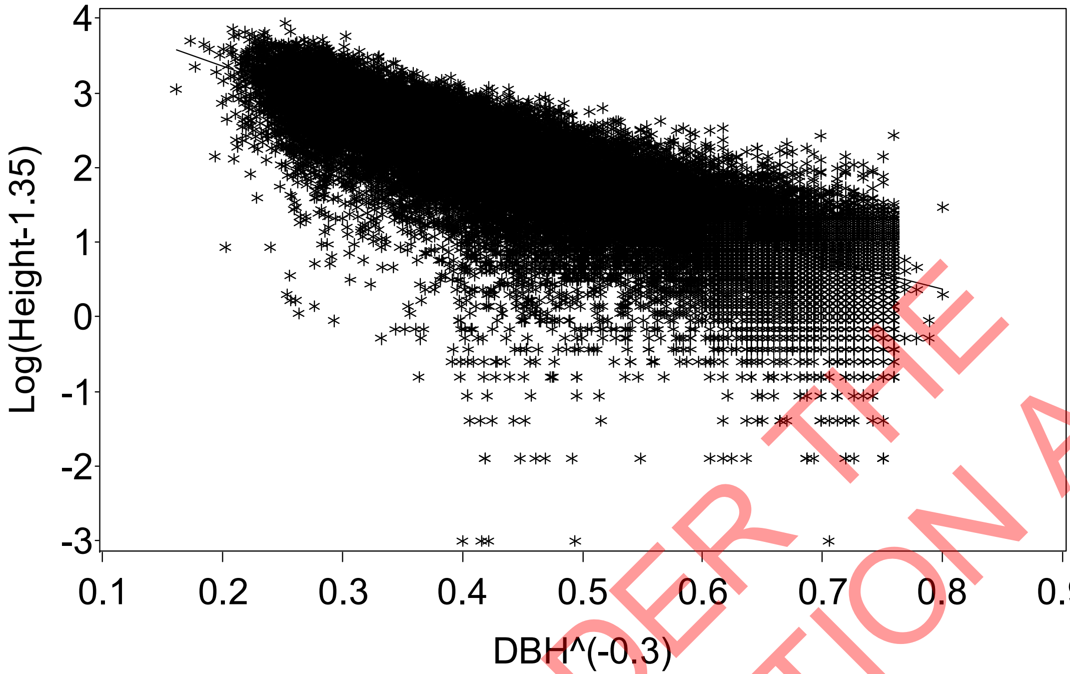

Fig. 4. Relationship between log(height-1.35) and DBH$^{-0.3}$ of all live, non-leaning stems in the database excluding tree ferns and vines.

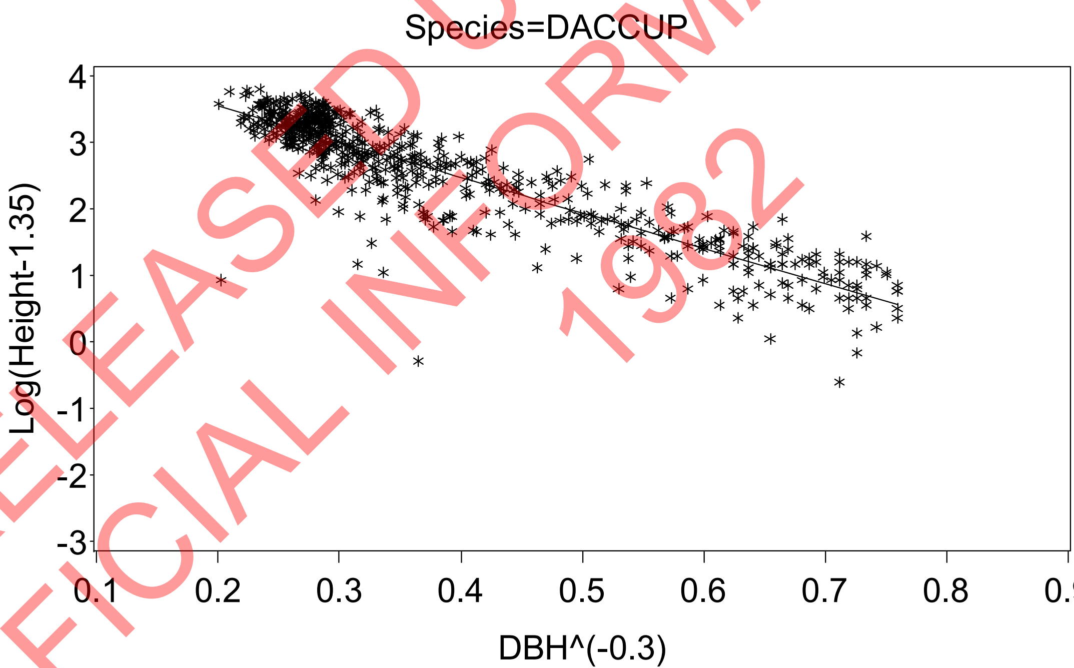

Fig. 5. Relationship between log(height-1.35) and DBH$^{-0.3}$ of all live, non-leaning *Dacrydium cupressinum* stems.

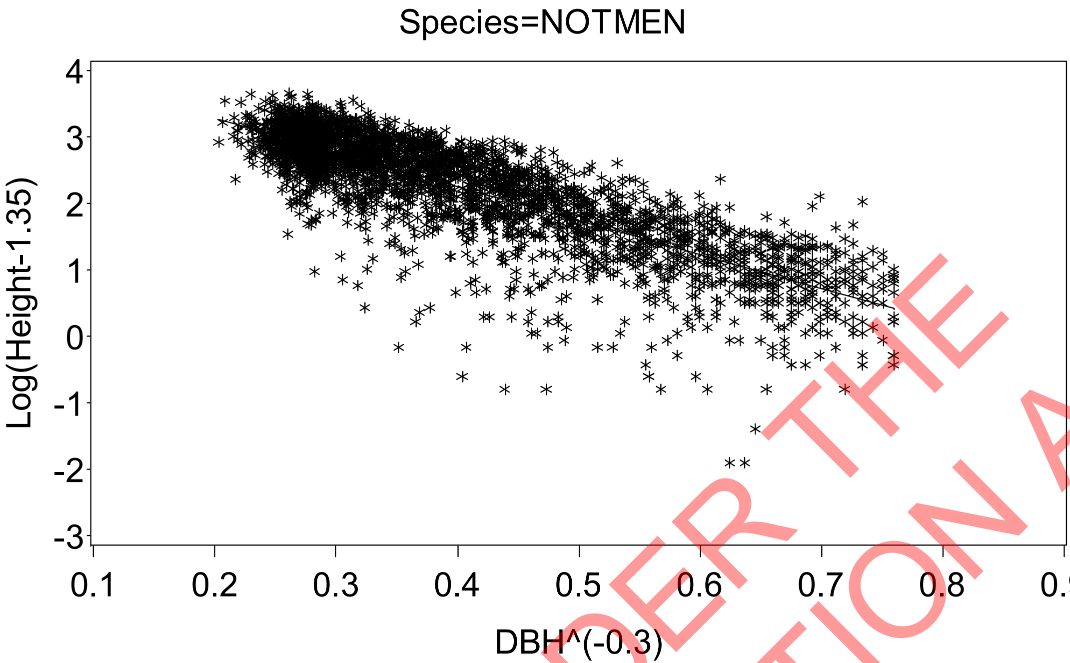

Fig. 6. Relationship between log(height-1.35) and DBH$^{-0.3}$ of all live, non-leaning *Nothofagus menziesii* stems.

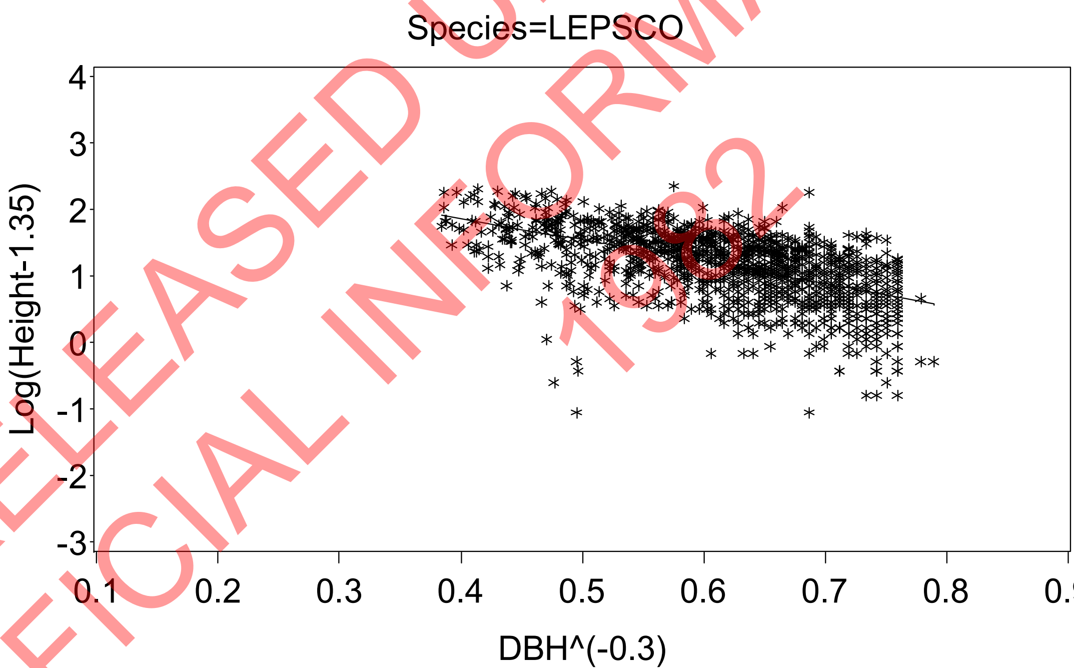

Fig. 7. Relationship between log(height-1.35) and DBH$^{-0.3}$ of all live, non-leaning *Leptospermum scoparium* stems.

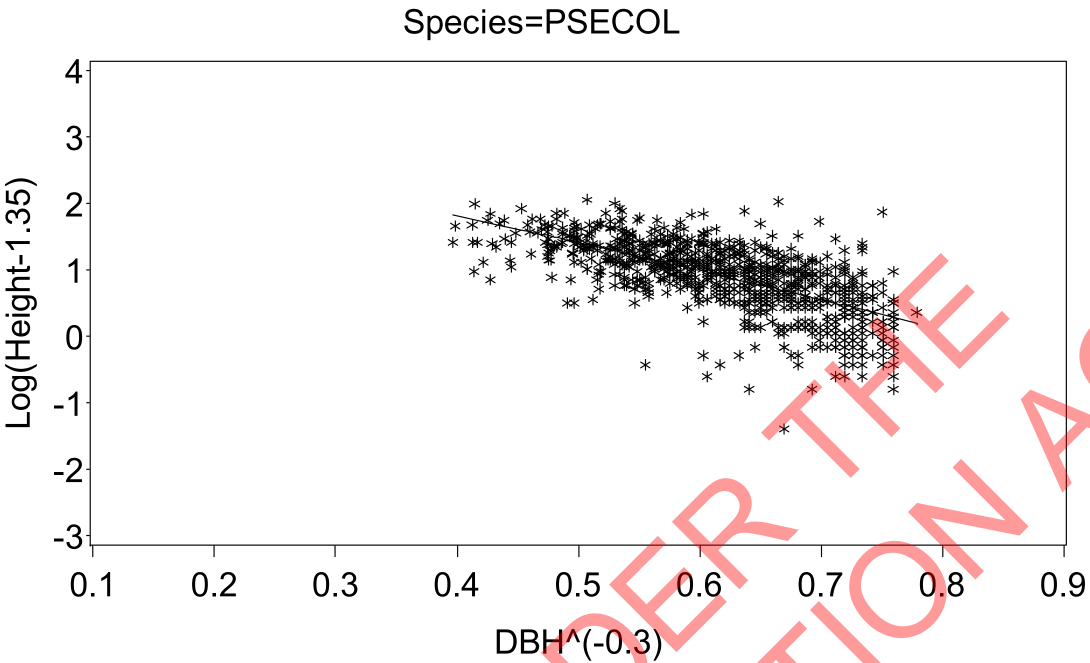

Fig. 8. Relationship between log(height-1.35) and DBH$^{-0.3}$ of all live, non-leaning *Pseudowintera colerata* stems.

When the linearized form of Model (1) was fitted to the data as a regression model, tests showed that both the intercept parameter *a* and the slope parameter *b* varied significantly between both plots and species. This suggests that separate height/diameter curves are required for predicting heights for each species within each plot. However, there were generally not enough trees of each species measured within any single plot to allow a specific height v diameter curve to be calculated. In even-aged single-species plantations, the standard inventory approach is to estimate a common slope and intercept parameters for all plots within a stratum in the inventory. A model-based approach was therefore used.

The first step was to fit the following model based on the linearized form of the above height/diameter function:

(2) $$\ln\left(H_{ijk} - 1.35\right) = asp_i + aplt_j + bD_{ijk}^c + bsp_i D_{ijk}^c + bplt_j D_{ijk}^c + e_{ijk}$$

where H_{ijk} and D_{ijk} are stem height (m) and DBH (cm) respectively of the k^{th} stem of species *i* in plot *j*. This was fitted to all the live, non-leaning tree and shrub DBH/height measurements in the database excluding tree ferns and vines. The model was fitted as a random coefficient regression model using the statistical package GENSTAT Version 11. The intercept term for each plot ($aplt_j$) and the general slope term (*b*) were fitted as fixed effects, and the remaining terms as random effects. The error terms (e_{ijk}) were assumed to be identically independently distributed with a different variance, σ_i^2, for each species. This allowed for the fact that the variation in log-transformed height about the regression line clearly varied between species.

Parameters from the fitted Model (2) were used in Model (1) to estimate stems heights. The slope term *b* for species *i* in plot *j* was obtained from the fitted parameters in Model (2) using $b = bsp_i + bplt_j$. Two methods were considered for obtaining the intercept term a in Model (1). Method 1, which is suitable when a significant number of height stems of a given species are measured within a plot, obtains the intercept using these measured trees. Method 2, which is suitable when few or no height stems are assessed, uses the fitted intercept from Model 2. For Method 1, the intercept is obtained using a = mean of $(H\text{-}1.35)/\exp(bD^{-0.3})$ where the mean is calculated for the measured height trees in the plot. For Method 2, it is necessary to correct for the bias introduced by the log transformation in Model (2). This can be achieved using the standard bias correction procedure for log-transformed regression models of adding half the variance to the intercept. The intercept for Method 2 is therefore obtained using $a = asp_i + aplt_j + \sigma_i^2/2$.

The question then arose as to how to determine the optimum value of N, the number of height trees which should be available before Method 1 is used in preference to Method 2. This question was answered using a validation procedure. One third of the height stems in the database was set aside for use as a validation set, and Model (2) was fitted to the remaining 20,000 height stems. The bias and RMSE (root mean square error – the square root of the mean squared errors) for predicted versus actual height were then calculated for the validation trees using various values of N from 1 to 20. The results (Table 5) show that the RMSE is nearly constant when N is 3 or greater but is higher for N less than 3. This indicates that Method 1 should not be applied when only 1 or 2 height stems are available for a particular species in a plot, and that Method 2 is clearly preferable in this case. In fact, based on the RMSE, Method 2 could be used in all cases. However, Method 2 is slightly biased, over-predicting height on average by about 0.15 m. This is not particularly surprising as the bias correction procedure used for Method 2 only works perfectly when errors are normally distributed. Because of this, it was decided to use Method 1 when 3 or more height stems were available (true for 86% of CMS stems in the database) in all carbon pool calculations. However, because heights were not measured in historical NVS surveys, Method 2 was always used when calculating carbon stock changes.

Table 5.
Bias and RMSE of actual versus predicted height for validation height stems for various values of N.

N	Bias	RMSE
1	-0.06	2.54
2	-0.08	2.50
3	-0.10	2.46
4	-0.12	2.45
5	-0.13	2.47
10	-0.14	2.47
20	-0.15	2.46
Always use Method 2	-0.15	2.46

2.1.3 Height model for tree fern species
For tree fern species, there is no strong relationship between stem height and DBH. A simpler approach using means was therefore used to estimate heights of these species. When 3 or more stems of a given species in a given plot were measured for height, the mean height of the measured stems was applied to all stems of that species in the plot. To estimate heights when less than 3 stems of a given species were measured in a

plot, a modeling approach was used. The following linear model was fitted to all the tree fern heights in the database:

$$(3) \quad \ln(H_{ijk}) = sp_i + plt_j + e_{ijk}$$

where the error term e_{ijk} was assumed to be independently normally distributed with variance σ^2. In cases where less than 2 stems of a species were measured for height, the bias-corrected estimate $sp_i + plt_j + \sigma^2/2$ was used.

2.1.4 Stem Volume of live trees

Over-bark stem and large branch (≥10cm in diameter) volume V (m^3) of stems measured for DBH other than tree ferns were predicted using the allometric equation of Beets et al. (2008b). When height was measured, and the stem was not classed as leaning, this was used in the equation. Otherwise height was estimating using the procedure described above. The allometric equation is:

$$(4) \quad V_{stem} = 0.0000483 \times (D^2 \times H)^{0.978}$$

An allometric relationship for stem volume of tree ferns is not currently available. It was therefore assumed that tree ferns are cylindrical, and stem volume based on the height and DBH was estimated using:

$$(5) \quad V_{treefern} = \pi D^2 \times H/40{,}000$$

Note however, that stem volume was not used to estimate the carbon content of live or standing dead tree ferns, which were estimated directly from DBH and height (Beets et al., 2008b).

2.1.5 Stem Volume of standing dead trees and spars

The following procedure was used to estimate the volume of standing dead stems, which often occurred as spars. The volume of each truncated stem was estimated using a taper function (T468) developed by Mina van der Colff of Scion using stem sectional measurement data acquired for a subset of the native forest trees included in the allometric functions report (Beets et al. 2008b). A total of 115 of these trees included stem sectional measurements (Table 6), which covered a wide range dimensions.

Table 6.
Dimensions of native trees with sectional measurements.

	n	Minimum	Mean	Maximum	Std Dev
DBH	115	5.3	52.9	142.0	34.7
Ht	115	7.7	27.9	59.2	12.7
Stem volume$_{ob}$	115	0.011	5.46	32.1	7.91
Form factor	115	0.254	0.485	0.691	0.078

The taper function (T468) provides estimates of the volume for stem section between any two specified heights. Table 7 provides estimates of the volume of the stem section between 0.15 m and 12.15 m height above ground for trees differing in DBH and total height, as an example.

Table 7.
Volume over bark of stem section between 0.15 m (first) and 12.15 m (second) height, estimated using taper function T468 for indigenous trees in natural forest.

DBH (cm)	Tree total Height (m)	Vol_{ob} (m^3)	DoB (cm) – first level	DoB (cm) – second level	$Vol_{section}$ (m^3)	$Vol_{section}$ (%)
37	33	1.89	52.7	30.3	1.17	62
57	32	3.86	76.3	43.6	2.44	63
57	39	4.88	78.9	46.6	2.67	55
57	45	5.79	80.8	48.6	2.84	49
78	43	9.44	105.3	63.0	4.80	51

The volume of dead stems and spars was estimated in two steps using Equation (6) and Equation (7) as follows. Firstly, the estimated height H_L (m) of a live stem of the same DBH, species and plot was calculated using the live stem height/diameter function described above. If the actual height of the stem H was not measured, it was assumed to equal H_L. If H_L was less than H, H_L was set to H. The over-bark stem volume of the original live stem V_{468} (m^3) was then estimated using Volume Function 468:

(6) $$V_{468} = D^{1.7347}(H_L^2/(H_L\text{-}1.35))^{1.2354}\text{Exp}(-9.9996)$$

The volume of the truncated stem was then estimated using:

(7) $$V_{deadstem} = V_{468}\,(1\text{-}0.06501x^2\text{-}2.92127x^3\text{-}3.37103x^4\text{-}1.35551x^5\text{-}0.02924x^{81})$$

where x = $(H_L\text{-}H)/H_L$. For tree ferns, Equation (5) was used for dead as well as live stems.

2.1.6 Stem carbon of live trees
For live tree stems and large branches (≥10 cm diameter), excluding tree ferns, carbon (kg) was estimated from volume using:

(8) $$C_{stem} = D_{stem} \times V_{stem}/2$$

where D_{stem} (kg dry matter/m^3) is whole stem and large branch wood plus bark density tabulated by species (Appendix 3). For species with no tabulated density, mean density of the genus, or failing that, of the plant type was used.

Branches (<10cm diameter) and foliage carbon (kg) of live trees were estimated directly from DBH (cm) using the equations of Beets et al. (2008b), i.e.,

(9) $$C_{branch} = 0.0175 \times D^{2.20}$$

and,

(10) $$C_{foliage} = 0.0171 \times D^{1.75}$$

These estimates were combined to calculate total above ground carbon for live trees:

(11) $C_{AGlive} = C_{stem} + C_{branch} + C_{foliage}$

For tree ferns, carbon was estimated directly from DBH (cm) and height (m) using the equation of Beets et al. (2008b):

(12) $C_{treefern} = 0.00457 \times D^2 \times H$

Carbon estimates of individual stems (kg) were summed and converted into t/ha using the plot horizontal area. For stems ≥60 cm DBH, a plot area of 0.1257 ha (the area of the 20 m radius external plot) was used, while for smaller stems, a nominally 20 x 20 m plot horizontal area was calculated as described in Section 2.1.15.

2.1.7 Crown volume of discrete shrubs

The cuboid volume (m^3) occupied by the crown and stem of each discrete shrub was calculated as follows:

(13) $V_{discrete\ shrub} = (W1 \times W2 \times H)$

where W1 and W2 are the orthogonal width (m) of discrete shrubs (or individual clumps) with W1 measured at the widest point, and H is the natural total height (m) of each discrete shrub.

2.1.8 Carbon of discrete shrubs

For shrubs measured using the discrete method, allometric relationships between shrub carbon and the shrub dimension (orthogonal widths and height) were developed using the sample of discrete shrubs harvested nearby each of the main plots. The relationship between carbon (dry matter/2) and crown dimension was weak, although because of the wide range in plant sizes, when the variables were expressed on the log scale, a reasonable relationship was found using the following model:

(14) $\log(C_{discshrub}) = a + b\log(W1 \times W2) + c\log(H)$

where $C_{discshrub}$ is carbon (kg), H (m) is shrub height, and $W1 \times W2$ (m^2) is the product of the two measurements of shrub width. However, the relationship was found to vary very significantly between both species and plots. A much better model was found by expressing the intercept a as the sum of species and plot effects $a_{plot} + a_{species}$.

A summary of these models is given in Table 8. The more complex model has a much superior fit, and estimates for both b and c are both close to one indicating for a given species in a given plot that carbon scales proportionately to the product of the 3 plant dimensions $H \times W1 \times W2$. However, when species and plot effects are not included in the model, the estimate for c is not significantly greater than zero indicating no significant relationship between plant carbon and plant height.

Table 8.
Summary of regression models for estimating carbon in shrubs using the discrete assessment method.

Terms in model	R^2	*b (s.e.)*	*c (s.e.)*
log(*W1xW2*), log(*H*)	0.72	0.94 (0.04)	0.12 (0.08)
species, plot, log(*W1xW2*), log(*H*)	0.94	0.86 (0.05)	0.93 (0.13)

The more complex model indicates that for a given species and plot, carbon is proportional to crown volume for discrete shrubs. Therefore, the ratio of means estimator (discrete shrub total dry weight/cuboid volume) was fitted by species and plot, to estimate above ground shrub carbon from the discrete shrub dimensions of plot shrubs:

$$(15) \quad C_{DiscreteShrub}\ \text{(t/ha)} = \sum_{Species} \left(\frac{\sum_{Harvested} (DryWeight)/2000 \times \sum_{Plot} \mathrm{V}_{\text{discrete shrub}}}{\sum_{Harvested} \mathrm{V}_{\text{discrete shrub}}} \right) \Big/ PlotArea$$

where *DryWeight* is the total dry weight (kg) of discrete shrubs, and $V_{discrete\ shrub}$ (m^3) is the cuboid volume as defined previously, and *PlotArea* is the horizontal area of the nominally 20 x 20 m main plot expressed in hectares (as described in Section 2.1.15).

Where a species present in a given plot was not harvested, the ratio of means estimator was based on all other species harvested for that plot. If no discrete harvest data were obtained for a given plot, then the ratio of means estimator was based on all other species harvested from other plots (1.029). Discrete samples were not obtained if the plot was measured predominantly using the continuous shrub method, and therefore this data limitation is likely to have minimal impact. The ratio of means gave similar estimates as the more complex species and plot specific allometric model described above, and was therefore considered preferable.

2.1.9 Canopy volume of continuous shrubland

The cuboid volume (m^3) of continuous shrubs in a 20 x 20 m plot was calculated from the area occupied by continuous shrubs and shrub mean height by subplot and summed for all subplots with continuous shrub area data as follows:

$$(16) \quad V_{continuous\ shrub}\ (m^3) = (\textstyle\sum (A_{shrubcov} \times H_{quadrant})) \times (PlotArea/0.04)$$

where

$A_{shrubcov}$ = cross-hatch nominal area (m^2) of continuous shrub cover, assessed in the field as squares, rectangles, triangles, or a combination of these shapes, summed by subplot assuming each subplot is 5 x 5 m in area. The ratio *PlotArea*/0.04 is included to correct for the fact that these areas are measured on the slope and assume that the 16 subplots have a total area of 0.04 ha

$H_{quadrant}$ = is mean height (m) of shrub cover at defined quadrants by subplot.

Distance measurements corresponding with cross-hatched areas (in Appendix 9 of Payton et al. 2004) were converted to continuous shrub covered areas, using the formula for a rectangle (X1 × X2) for squares and rectangle shapes, and a general triangle (Heron's formula) for triangular shapes. For triangle shapes:

(17) $A_{triangle} = (s \times (s - X1) \times (s - X2) \times (s - X3))^{0.5}$

and

(18) $s = ½ \times (X1 + X2 + X3)$

The mean height of shrubs of subplot "A" was defined as the mean height recorded at quadrants 1, 2, 9, and 10, while the mean shrub height of subplot "B" was based on 2, 3, 8, and 9, etc., as shown in Fig. 4a in Payton et al. 2004). Furthermore, quadrants with zero height recorded (shrubs were less than 0.3 m in height at that point), were included in the mean for the subplot, as were quadrants with non-zero heights but without continuous cover (based on shrub cross-hatch map) present. The latter situation implies that a discrete shrub occurred at that quadrant – these heights must be included in the mean in order that carbon stock changes are correctly estimated in future.

2.1.10 Carbon of continuous shrubland

The plot layout data were used to estimate the horizontal area of each biomass plot. The horizontal area of rectangular biomass plots (m^2) (nominally 2 x 1 m or 4 x 1 m on slope) was calculated as follows:

(19) *BiomassPlotArea* (m^2) = (LongAxis1 +LongAxis2)/2 x (ShortAxis1+ShortAxis2)/2

where

LongAxis1 = LongAxis1_TapeDist x COS (LongAxis1_Slope x π / 180)
LongAxis2 = LongAxis2_TapeDist x COS (LongAxis2_Slope x π / 180)
ShortAxis1 = ShortAxis1_TapeDist x COS (ShortAxis1_Slope x π / 180)
ShortAxis2 = ShortAxis2_TapeDist x COS (ShortAxis2_Slope x π / 180)

are the slope corrected tape distances of the biomass plot sides.

The cuboid volume (m^3) of continuous shrubs in biomass plots was calculated from shrub mean height assuming that the biomass plots were installed in an area occupied by continuous shrub as follows:

(20) V_{BP} (m^3) = ($BiomassPlotArea \times H_{BPquadrant}$)

where

$H_{BPquadrant}$ = is mean height (m) of shrub cover in biomass plot.

The mean height of shrubs in biomass plots was defined as the mean height recorded at quadrants 1 – 10 when one nominally 4 x 1m biomass plot was installed as shown in Fig. 4b in Payton et al. (2004), or at quadrants 1 – 6 or 1 – 12 when nominally one or two 2 x 1 m biomass plots, respectively were installed.

The relationship between shrub carbon (t/ha) and cover mean height (m) was examined, but unfortunately, no significant relationship was found. The R^2 of a regression between biomass carbon per unit area in the biomass plot and quadrant mean height was 0.05, while a more complex model containing height, predominant species, and cover score, had an R^2 of 0.22 with none of the independent variables being statistically significant. This result is not particularly surprising given that 1) continuous cover biomass harvest plots included a mixture of shrub species and 2) that the analysis of the discrete data described above found no overall relationship with height across all species and plots, although a proportional relationship existed at the individual species x plot level.

For the continuous shrub method, normally only one biomass plot was assessed per site. Therefore, it was not possible to test for site differences. However, on the basis of the discrete data analysis, it can be safely assumed that such differences exist. Furthermore, on the basis that the discrete shrub data analysis revealed a good relationship between shrub height and carbon at the plot and species level, it seems likely that similar relationships must also exist for continuous cover data at any particular site. Furthermore, for subplots within the 20 x 20 m main plot that are fully occupied with continuous shrubs, a stock change following re-measurement of the plots will depend on height growth. It was therefore decided to scale the biomass data according to the ratio of the mean shrub canopy volume across the 16 subplots to the mean cuboid volume of the corresponding biomass plot (Equation 21).

(21) $C\ (t/ha) = (DryWeight/2000) \times (V_{continuous\ shrub}/V_{BP}) \ /\ PlotArea$

where,
DryWeight (kg) is the oven dry weight of shrubs in the continuous cover biomass plot. It is noted that *PlotArea* in equation 21 cancels out the effect of *PlotArea* in equation 16, but was included in both equations for clarity.

Where no continuous harvest data were acquired for a given plot, DryWeight and V_{BP} were replaced by the means from all the continuous biomass plots (Mean DryWeight = 12.29 kg, and Mean V_{BP} = 4.057 m^3) in equation 21. Continuous shrub biomass samples were not obtained if the plot was measured predominantly using the discrete shrub method, and therefore this data limitation is likely to have minimal impact.

The alternative approach to using equation 21 would be to scale the carbon from the biomass subplot only by the cover area, and to ignore height. Both approaches were found to give similar results. However, because mean quadrant heights of biomass subplots were slightly greater on average those in the main plots, estimates scaled using both height and cover area were 5% less than those scaled by cover area alone.

It should be noted that if subplots were assessed using both the continuous cover and tree methods (ie, DBH measured), the above calculations may double count shrub biomass carbon. Double counting would occur if the area of crowns assessed as trees was included in the area estimate for continuous cover shrubs. Double counting obviously occurred in subplots with similar sized shrubs (some measured as trees, some not) with a cover area of nominally 25 m^2 for the subplot, and may also have occurred in subplots not fully occupied by continuous cover shrubs.

2.1.11 Carbon stock in below ground biomass

The carbon in below ground biomass was assumed to comprise 25% of the carbon in above ground biomass. This factor was applied both to trees and shrubs following Coomes al. (2002).

2.1.12 Volume of logs and stumps measured as coarse woody debris

CWD volume >10cm in diameter was estimated from the large and small end orthogonal diameters (LED1, LED2, SED1, SED2) and length (L) of individual log sections using the formula for a truncated cone:

(22) $CWD_{vol}\ (m^3) = 1/3 \times (\pi \times L) \times ((LED/2)^2 + LED/2 \times SED/2 + (SED/2)^2)$

where

$LED = (LED1 \times LED2)^{0.5}/100$

$SED = (SED1 \times SED2)^{0.5}/100$

The volume of stumps less than 1.35 m in height, for which orthogonal diameters at the upper end of the stump were recorded, was estimated using the formula for a cylinder. This approach is consistent with how stem volume of live trees is calculated (where the formula for a cylinder is applied from ground level to stump height (0.15 m above ground where the lowest diameter is measured) and the truncated cone formula is used thereafter to a 10 cm diameter top.

2.1.13 Carbon in coarse woody debris (both standing and fallen)

CWD volume estimates of stems (excluding tree ferns) were converted to carbon using whole stem and large branch wood plus bark density over bark, as tabulated for live trees by species in Appendix 3. These were then reduced using modifiers tabulated by decay class (Appendix 5) to account for the density reduction due to the state of decay as follows:

(23) $C\_CWD\ (kg) = (CWD_{vol} \times D_{stem} \times D_{stem\_mod})/2$

(24) $C\_SPAR\ (kg) = (V_{deadstem} \times D_{stem} \times D_{stem\_mod})/2$

Carbon in individual fallen log sections, stumps, and spars were summed per plot and divided by the plot horizontal area to provide CWD carbon stock at the time of the LUCAS measurement for spars and CWD less than 60 cm diameter. For standing stems larger than 60 cm DBH and for fallen CWD with either LED or SED greater than 60 cm, a plot area of 0.1257 ha was used. When calculating carbon change from NVS plots, Equation (25) was used for all material including that greater than 60 cm diameter.

(25) $C\_CWD_{D<60}\ (t/ha) = (\sum C\_CWD + \sum C\_SPAR)/1000/PlotArea$

(26) $C\_CWD_{D>60}\ (t/ha) = (\sum C\_CWD + \sum C\_SPAR)/1000/0.1257$

(27) $C\_CWD_L = C\_CWD_{D<60} + C\_CWD_{D>60}$

where C_CWD_L is the total CWD at the time when the LUCAS plot was measured.

A different approach was used for estimating CWD for tree ferns. Equation 12 for estimating carbon directly in the live tree ferns was used, and the estimate reduced using modifiers for unknown species (Appendix 5) to account for the state of decay.

Carbon in standing dead stem and spars > 10 cm in DBH was reported as part of the CWD pool. Carbon in standing dead stems and spars <10 cm in DBH was not estimated because these stems were not measured (Payton et al. 2002), so total carbon will be slightly underestimated. Standing dead stems from 2.5 - 10 cm in DBH were sometimes measured (for example in some NVS plots), but not consistently for all plots, so these data were therefore excluded from the analysis.

2.1.14 Carbon stock in fine woody debris and litter and FH(O)

The carbon stock per ha of FWD, litter, and FH(O) on the forest floor was calculated from the carbon mass, the litter collection area, and a slope correction factor.

Quadrat slope data

All original measured slope data was kept unchanged (PlotSlopeArea Table) and rules were applied to the data set to fill gaps and remove anomalies, creating a new data set with a combination of the original and calculated or assumed slope values. Exceptions and calculations applied to the slope data set are explained below with the following rules:

Table 9.

Exception and calculation rules applied to the soil sampling slope data set.

Reason for no slope measurement	Description
Plot abandoned	Where the plot was not visited – no slope measurements.
Time	Where sample points (quadrats) were not visited due to time constraints – no slope measurements.
Abandoned	Where slope was equal to or greater than 90 degrees (ie zero horizontal area allocated). Two examples only: BK93-D-Slope2, a slope of 102 degrees (ie undercut) and BL96-A-Slope3, a slope of 90 degrees (ie vertical) – quadrat slope removed from data set. One example of a plot quarter in a residential flower garden – point was not sampled (eg CH41-P) – no slope measurement.
Not measured	Missing slope measurements. Where only one slope was measured at each quarter it is assumed that the remaining two slopes were equal to the measured slope. Where two slopes where measured, the horizontal projection given the measured slopes was used to calculate the missing slope value. Where no slope on the sample point was measured, no value has been entered into the table. A total of 129 have no individual quarter sample point slope measurements.
Obstruction	Where slope was not measured due to an obstruction, eg CWD, tree root buttress, or large boulder(s). The rule above for 'Not measured' was applied.
In tree	Where the collection quadrat was within a large tree (eg CN95-A-Slope2 and 3, CW81-M-Slope2 and 3, DM58-A-Slope2). The rule above for 'Not measured' applies.
In stream	Two plots (BU22 and CB73) had sample points in a stream. No slope was measured and was assumed to be 0 degrees.

Slope Correction factor for litter and fine woody debris
A slope correction ratio was required to express C stock estimates on a horizontal area basis. Three methods were used to calculate a slope correction ratio dependent on the data available.

Both Litter and FWD were collected using the $0.1m^2$ quadrats and where individual sample point slopes were measured the horizontal area was calculated for each individual sampling quadrat. A slope correction ratio per quarter (QuarterRatio) was calculated using the sum of the sampling area for each quarter over the sum of the horizontal area for each quarter. The QuarterRatio could only be used in C content calculation where samples were weighed by quarter (e.g. all plots for FWD and LFH(O) plots with individual dry weights and carbon analysis per quarter).

Where individual sample weights per quarter were unknown, ie samples were bulked by plot in the laboratory, a plot ratio (PlotRatio1) was calculated from the sum of the sampling area for all quadrats over the sum of the projected horizontal area for all quadrats (a total of 185 plots for litter). Where no slopes were measured at individual sampling points the average plot slope, from the LUCAS table t520, was used to calculate a plot ratio (PlotRatio2).

C Content Calculations
The carbon content for FWD, Litter and FH samples was calculated for each quarter using Equation 28 and averaged for each plot.

(28) $$C(t.ha^{-1}) = mean\left(\left((C\%/100) \times (Mass/Area)\right)/100\right)$$

Where;
C% = percentage of total carbon of the oven dry mass per quarter (assumed to be 50% in case of FWD),
Mass = oven dry mass per quarter (g)
Area = slope corrected area per quarter (m^2),

Where slope or dry weight data were not measured on a quarter basis, a total slope corrected carbon content was calculated on a plot basis using the weighted C percentage, sum of mass and collection area and PlotRatio3.

Litter subsampled in field
Where large sample volumes were collected a representative sub-sample could be taken in the field before submitting to the laboratory. The correct Litter weight could then be calculated based on the field total and sub-sample fresh weights and laboratory sub-sample oven dry weight. A total of 4 Litter samples were sub-sampled in the field (BI109, BO106, BR104, Q181).

FH sample collection and bulking for analysis
FH was collected using a combination of methods, depending on the thickness of the layer. Where FH was thin a quadrat (0.1 m^2) was used and where the FH was thick (typically >20 mm) a core (0.007543 m^2) was used to collect the sample. Mixed methods of sampling occurred between quarters within some plots, and where quarters were bulked in the laboratory by plot, the carbon stock estimate obtained using Equation 28 would be greatly biased. As a result, for all FH samples that were

bulked in the laboratory, a total sample density (excluding gravels) was calculated from the sum of the sample FH mass over the sum of the sample volume (area x measured FH depth). The total bulk density multiplied by the average sample depth per quarter gave the FH mass (t/ha) per quarter which were averaged to give the FH mass per plot. The FH carbon stock was calculated using Equation 29.

$$(29)\quad C(t.ha^{-1}) = ((mean(BD \times Depth) \times 10) \times (C\%/100)) \times PlotRatio$$

Where;
C% = percentage of total carbon of the oven dry mass per plot,
BD = total sample bulk density on a plot basis (g/cm3)
Depth = average sample depth per quarter (mm)
PlotRatio = slope correction applied (PlotRatio3)

In cases where the FH was collected using a quadrat and a core from within one of the sampling quarters the FH mass (t/ha) for each sampling point was calculated and then averaged for that quarter before the plot average was calculated (all examples are AQ163, AU146, BK94, CR43). Note CR43 and AQ163 were analysed on an individual quarter basis in the laboratory, however, at one quarter the FH was sampled using a quadrat and a core and Equation 29 was used for the carbon stock calculation.

Note: Sample BG97 O horizon used Equation 29 as two cores were collected from one quarter and one core from the second quarter (the other two were abandoned).

The checked and formatted forest floor (FWD, L, FH(O)) carbon stock per ha estimates, as described by Garrett (2009), were merged with the tree, shrub, and woody debris estimates per ha from the LUCAS database.

2.1.15 Slope correction of main plot data

The plot layout data were used to estimate the horizontal area of each plot (Appendix 2). The actual horizontal area of a nominally 20 x 20 m square plot laid out on a slope was calculated as follows:

Assuming that plot corners are right angles, the area of a nominally 20 x 20 m square plot can be closely approximated using the following formula:

(30) *PlotArea* (ha) = ((AD+PM)/2 x (AP+DM)/2)/10,000

where AD (Line = 1), PM (Line = 3), AP (Line = 4), DM (Line = 2) are the sum of either the slope corrected tape distance or Vertex distance measurements of each plot side in metres. Horizontal distance measured directly using a Vertex was used in all but 15 plots.

In many cases, the terrain was such that plot corners were not all right angles, and the measured tape distances were not all 20 m. If at least one angle (eg, the angle between PM and DM) was a right angle, the simple formula (Equation 30) can be shown to on average overestimate the horizontal area of plots by 0.2% - compared with estimates obtained using a theoretically accurate formula that estimates horizontal areas using the combined right triangle/general triangle formulas. In practice, the combined formulae did not confer any clear advantage over the simple formula, but may have disadvantages (eg. if bearings were not measured accurately) so the simple formula was preferred.

In most cases the Vertex distance measurements were used, unless obvious measurement errors occurred or the data were missing, when slope corrected tape distances were used. The circular (20 m radius) plots were installed on a horizontal basis, so no slope correction was required.

2.1.16 Classification of plots by cover type

New Zealand's natural forest has been classified into EcoSat Forest types (Shephard et al. 2005), which was derived by combining Landsat ETM+ satellite imagery with the New Zealand Land Resource Inventory. ETM+ satellite imagery provided accurate boundaries of NZ's current indigenous forest estate, while evidential reasoning was used to assign forest classes within the boundaries. EcoSat Forests underlying data have an intrinsic scale of 1:50,000.

The area of shrubland was obtained by subtracting the sum of the EcoSat forest areas by island from the LCDB1 area of total forest and shrubland. The forest and shrubland classes include some areas noted by field teams as planted with exotic species. These plots were used to estimate the area of each EcoSat forest type planted with exotics on the assumption that each plot represents 1/1256 of the total area or 7081 ha, and were subtracted from the natural forest areas. EcoSat Forests gives a slightly higher natural forest area than was obtained using LCDB1, and consequently the area of shrubland, which was derived by subtracting the adjusted EcoSat Forest areas from the LCDB1 forest and shrubland total area, is slightly less than reported by the LCDB1 shrubland class.

An alternative to using pre-defined forest types such as the EcoSat classes was to classify plots on the basis of their species composition. A cluster analysis based on the distribution of AGB in the dominant species was performed to test this approach. The variables used in this analysis were the AGB carbon (t/ha) of the 27 most important species. These were calculated for each plot, and log transformed to reduce the influence of extreme observations. A cluster analysis was performed using the SAS FASTCLUS procedure which produced 12 classes. Plots assessed using the shrub biomass method could not be included in this analysis and were grouped into a separate class, as were planted exotic forest plots. Therefore, this analysis resulted in each LUCAS plot being assigned to one of 14 classes on the basis of the composition of the dominant species in the plot.

2.1.17 Stratification procedure used to estimate carbon stocks

LUCAS plots were located on a grid ensuring that they formed a systematic sample of the entire LCDB1 indigenous forest and shrubland population. However, standard errors were calculated using standard sampling formulae. These standard errors are likely to be conservative as in natural populations systematic sampling generally gives more precise estimates than random sampling (Cochran, 1977).

Further refinement of estimates and standard errors was achieved using stratification, with plots assigned to strata defined by the EcoSat forest types within each island. These formed 22 strata with known areas as shown in Table 10. Within stratum h, the mean $\bar{c}_h$ and standard error se_h of per ha carbon pools was calculated using standard formulae. Estimates across strata were calculated (eg, Cochran, 1977):

$$(31)\quad \bar{c}_{str} = \sum A_h \bar{c}_h \Big/ \sum A_h$$

where A_h is the area in stratum h, with standard error:

$$(32)\quad se(\bar{c}_{str}) = \sqrt{\sum A_h^2 se_h^2 \Big/ \sum A_h^2}$$

Estimates of total C pools in Mt were obtained similarly:

$$(33)\quad C_{str} = \sum A_h \bar{c}_h$$

with standard error:

$$(34)\quad se(C_{str}) = \sqrt{\sum A_h^2 se_h^2}$$

2.2 CARBON STOCK CHANGE ESTIMATION METHODOLOGY FOR FOREST PLOTS

2.2.1 General approach

Carbon stock changes for above ground components were estimated using the historic NVS forest plots (there were no NVS shrub plots) that formed part of the LUCAS network. Only two measurements were used for each plot. These consisted of the latest measurement which will be referred to as the 'LUCAS measurement', and the earlier measurement closest to the year 1990 which will be referred to as the 'NVS measurement'. LUCAS measurements were made between 2002 and 2006 (with average year 2004) while the chosen NVS measurements were made between 1975 and 2000 (with average year 1984). A total of 166 plot, or 13% of the total LUCAS network, were used in the analysis. Pools were reported by forest type, species, conifer versus broadleaf.

2.2.2 Live tree above ground carbon stock change

Because stem heights were not generally recorded in NVS assessments, it was necessary to estimate them using the height/diameter relationships established for the LUCAS measurement. The model based Method 2 was therefore used for estimating all stem heights for both LUCAS and NVS measurements (see Section 2.1.2). Estimating NVS measurement heights using the LUCAS height/diameter relationship within a plot is valid as long as the relationship remains constant over time. Generally, in uneven-aged stands with stems covering a wide range of sizes and ages, this is a reasonable assumption. However, when stands consist predominantly of a single cohort (e.g., in even-aged plantations) there is a tendency for the intercept term of the height/diameter relationship to increase over time. In this case, the above methodology will tend to overestimate earlier heights, and consequently underestimate height growth rates. Because of the uneven-aged nature of the populations sampled in this study, we believe that NVS height predictions should generally be sound, but if anything height growth rates could be slightly underestimated.

Height growth of tree ferns could not be estimated using the above approach because of the lack of any useful relationship between height and diameter for these species. Therefore, it was decided to assume a constant height growth rate for all tree ferns in the study. Very little data on height growth rates of tree ferns is available. However, some information could be gleaned from the database itself. Stems are only recorded in the database if they are at least 1.4 m in height. Therefore, the distribution of H_I = (H-1.4)/Y, where H is height (m) and N is the number years between the LUCAS and NVS assessments, gives some information on height growth rates. For ingrowths, the larger values of H_I should be from stems just under 1.4 m height at the NVS assessment, while for stems identified in both assessments, the smaller values of H_I should be from those just over 1.4m height in the NVS assessment. For example, we might assume that the annual height growth rate could be provided by the 75th percentile of ingrowths (0.18m/yr) or by the 25th percentile of stems identified in both assessments (0.09m/yr). We believe that many existing tree ferns may not have been recorded during NVS measurements meaning the identification of 'ingrowths' is problematic and that more reliance should be placed on stems identified in both assessments. Therefore, we assumed a height growth rate of 0.1 m per year for all tree ferns in the study. In summary, heights of tree ferns in NVS measurements were obtained by subtracting 0.1 m from the LUCAS height estimate for each elapsed year. This approach was applied to ingrowths as well as to stems identified in both assessments. Furthermore, because diameters of tree ferns do not increase significantly with age, the LUCAS measured DBH was used for both NVS and LUCAS assessments for calculating stem volume and carbon.

Carbon estimates of all live trees were calculated using the procedures outlined in Section 2.1.5. Stems within the 20 x 20 m NVS section of the LUCAS plots that were measured closest to 1990 and at the LUCAS measurement were used to estimate growth. For ingrowths, carbon in the live pool at the NVS measurement was set to zero, while for stems that died between the NVS and LUCAS measurements, carbon in the live pool at the LUCAS measurement was set to zero. Annual carbon change in the above ground live pool was calculated as the difference between the LUCAS and NVS measurements, divided by the elapsed time in years, and expressed on a horizontal area basis for each plot to give a national stock change per ha per year. Contributions to the change in live above ground carbon from stems live at both assessments (growth), stems appearing for the first time in the LUCAS measurement (ingrowth), and trees that died between measurements (mortality) were calculated separately for reporting purposes. In future, carbon stock changes should include the growth of all trees within the 20 m circular plot, following remeasurement of the LUCAS plot network.

2.2.3 Categories assessed

The following three categories of tree contributed to the change in above ground live carbon - Trees that survived throughout the period, trees that appeared during the period as in-growth, and trees that died during the period.

2.2.4 Coarse wood debris carbon stock change

The summed contribution to the CWD pool from trees that died between the NVS and LUCAS measurements (C_MORT_{FRESH}) was estimated for each plot following Beets et al. (2008c), except with the modification that carbon in stems below the breakpoint (ie measured in LUCAS plots as spars) was not included. The contribution to CWD carbon from trees that died (C_MORT_{CWD}) was obtained from C_MORT_{FRESH} by adjusting to account for decay assuming that trees died midway between the time of the NVS and LUCAS assessments (T_N and T_L respectively) using the decay function given in Beets et al. (2008a):

(35) $C\_MORT_{CWD} = C\_MORT_{FRESH} \times \exp(-0.0229 \times (T_L - T_N)/2)$

An estimate of the residual carbon persisting from the CWD pool at the NVS assessment was obtained by subtracting C_MORT_{CWD} and C_{SPARS} (carbon in standing spar of mortality tree estimated using Equation (24), summed for all trees that died) from the above ground CWD pool (Section 2.1.13). The estimated proportional loss in mass over the period from the NVS to LUCAS measurements was obtained using the decay function and the NVS CWD stock was obtained by dividing the residual CWD by this proportion:

(36) $C\_CWD_N = (C\_CWD_L - C_{SPARS} - C\_MORT_{CWD}) / \exp(-0.0229 \times (T_L - T_N))$

Where C_CWD_L is the coarse woody debris carbon pool from Equation (25) and C_CWD_N is the estimated CWD pool at the NVS measurement. The change in CWD between the NVS and LUCAS assessments for each plot was divided by the elapsed time in years, expressed on a horizontal area basis for each plot, to give a national stock change per ha per year.

2.2.5 Fine litter stock change

This pool was not estimated. It is comprised of entire stems <10 cm DBH, fine attached material that is contributed by trees > 10 cm DBH following mortality, and forest floor LFH(O). To estimate the change in FWD using the methodology given here for CWD, decay functions will need to be developed. None are currently available. No method has been developed to estimate change in forest floor LFH(O).

2.2.6 NVS based carbon stocks and change estimates from 1990 to 2004

Unstratified estimates of above ground annual stock change (in t/ha/yr) were obtained from NVS plots. Per ha carbon pools were also obtained for each NVS plot for the standard years 1990 and 2004 by extrapolation from the CMS year using the annual change for the plot. Overall means and standard errors were obtained for annual stock changes, 1990 and 2004 pools, and differences. Means were also calculated for each island, for different forest types, and for individual species.

2.2.7 National carbon stocks and change estimates from 1990 to 2004

Because the subsample of NVS plots was much smaller than the larger sample of LUCAS plots, standard errors of C change estimates based on them were likely to be large. Furthermore, because NVS plots were not necessarily representative of the indigenous forest and shrubland population, estimates could potentially be biased. Therefore, to improve precision and reduce bias, two-phase sampling regression estimators of stock changes were calculated. These regression estimators used information from ancillary variables available across the larger (LUCAS) sample to improve the C change estimates from the (NVS) subsample. The two ancillary variables used for this purpose were the carbon per ha AGB and CWD pools which were available for all LUCAS plots.

Regression estimates were obtained by firstly fitting a multiple regression model between y the variable of interest (eg, carbon change from 1990 to 2004) and the ancillary variables x_i (AGB and CWD carbon), obtaining regression slope coefficients b_i for each variable. Multiple regression estimators and their standard errors were obtained using the methods given by Sitter (1997):

(37) $$\bar{y}_{reg} = \bar{y} + \sum_i b_i \left(\bar{x}_i' - \bar{x}_i\right)$$

(38) $$se\left(\bar{y}_{reg}\right) = \sqrt{s_e^2/n + \sum_i \sum_j b_i b_j \left(\left(\bar{x}_i - \bar{x}_i'\right)\left(\bar{x}_j - \bar{x}_j'\right) + s_{ij}\right) / \left(n'\left(n'-1\right)\right)}$$

Where n' is the number of LUCAS plots, n the number of NVS plots, $\bar{y}$ and $\bar{x}_i$ are the means of the dependent and independent variables in the NVS plots, $\bar{x}_i'$ are the means of the independent variables in the LUCAS plots, s_e^2 is the residual variance of the regression model on the NVS data, and s_{ij} the variance or covariance of the i^{th} and j^{th} independent variables in the LUCAS plots (eg, s_{11} is the variance of x_1).

RESULTS AND DISCUSSION

3.1 CARBON STOCK IN NEW ZEALAND'S NATURAL FOREST AND SHRUBLAND BY THE FOUR GPG POOLS AND WITHIN THE AGB POOL BY INDIVIDUAL TREE AND SHRUB SPECIES

Mean carbon stocks (in t/ha) and national totals (mean stocks x area, in millions of tonnes) in New Zealand's forest and shrubland reflect carbon in four GPG pools: 1) above ground biomass of trees > 2.5cm DBH and shrubs (AGB), 2) below ground biomass (BGB), 3) coarse woody debris (CWD), and 4) fine woody debris and litter (FD). Coarse woody debris arises from mortality of trees and branches > 10 cm in diameter, while fine debris arises from litterfall < 10 cm in diameter and mortality of trees < 10 cm in DBH.

3.1.1 EcoSat forest classes intersecting LCDB1 Forest and Shrubland

Areas in the ten EcoSat forest classes and one sub-alpine shrubland are shown by island in Table 10, which includes estimates of other shrubland based on LCDB1. The class areas in Table 10 are with and without applying a plot based adjustment for 22 planted exotic forest plots within the mapped indigenous forest and shrubland area. This adjustment was based on the assumption that each plot represents 1/1256 of the total area or 7081 ha. This implies that 156,000 ha within the LUCAS population is planted in exotic forest, and although this is a small proportion of the total area, it comprises a significant proportion of the national exotic plantation estate. North Island Coastal Forest was not represented by any plot in the LUCAS grid while the single plot classified as Podocarp Forest in the North Island was found to be planted in exotic forest. Coastal and North Island Podocarp forests were therefore grouped with the North Island Unspecified Indigenous forest type for the purposes of carbon pool calculations.

Approximately 60% of the total indigenous forest estate is located in the South Island/Stewart Is with the remaining 40% in the North Island. The split varies markedly with forest type, with 70 – 85% of the beech dominated forest types in the South Island/Stewart Is, while approximately 60% of the mixed broadleaved and unspecified forest types are in the North Island. Subalpine forest is predominantly located in the South Island (90%), while other shrubland is split almost 50/50 between the North and South Island. Kauri forest occurs exclusively in the North Island.

Table 10.
EcoSat forest class areas (1000 ha) with and without adjustment for planted exotic areas, shown by island and for New Zealand as a whole. When calculating carbon pools, Coastal and Podocarp Forest in the North Island were grouped together with the North Island Unspecified Indigenous Forest type.

Vegetation class	Without adjustment			With Adjustment		
	SI	NI	National	SI	NI	National
Beech / Broadleaved	69.7	28.8	98.4	69.7	28.8	98.4
Beech / Podocarp-broadleaved	771.3	218.3	989.6	764.3	218.3	982.5
Beech	1,828.2	360.9	2,189.1	1,828.2	360.9	2,189.1
Broadleaved	112.5	236.3	348.8	112.5	208.0	320.5
Coastal	0	5.2	5.2			
Kauri	0	91.7	91.7		84.6	84.6
Podocarp	57.3	7.9	65.3	57.4		57.4
Podocarp-broadleaved / Beech	377.8	469.0	846.8	377.8	469.0	846.8
Podocarp-broadleaved	447.9	800.5	1,248.3	447.9	800.5	1,248.3
Unspecified Indigenous	183.0	316.1	499.1	183.0	322.2	505.2
Total Indigenous	3,847.7	2,534.6	6,382.3	3,840.6	2,492.2	6,332.8
Subalpine shrubland	174.1	19.6	193.7	174.1	19.6	193.7
Other shrubland – by difference	1,175.0	1,142.7	2,317.6	1,125.4	1,086.0	2,211.4
Total Shrubland	1,349.1	1,162.2	2,511.3	1,299.5	1,105.6	2,405.1
Planted forest				56.7	99.1	155.8
Total area	5,196.8	3,696.9	8,893.6	5,196.8	3,696.9	8,893.6

3.1.2 Total carbon per plot (t C/ha)
The plot number, total carbon stock, and disposition by GPG pool are given for each plot in Appendix 2 which also contains information on forest type, plot horizontal areas (of the nominally 20 x 20 m square plot), region, and over bark volume of stem plus large (≥10 cm) branches required for preparing summaries by forest type, region, island, and national. Detailed plot level information is in a separate spreadsheet.

3.1.3 Mean plot-level carbon stock per ha for forest and shrubland, summarised for GPG pool by major vegetation type, and average carbon pool by island and forest class
The mean carbon stocks (and 95% confidence intervals) over all vegetation types and for indigenous forest, shrubland, and exotic planted forest mapped as indigenous forest are shown by GPG pool in Table 11. Overall, 80% is in living biomass and 20% in dead organic matter. The latter did not include standing dead stems < 10 cm in DBH. Fine debris includes LFH (O), and is mostly comprised of humus (H). Indigenous forest plots contained the largest pool of carbon per ha, followed by planted forest (mapped as natural forest and shrubland by LCDB1). A large number (148 of the 341 EcoSat classified shrubland plots) were classified by field teams (following Payton et al., 2004) as indigenous forest, which partly explains why the carbon stock per ha of shrubland plots is relatively high, at approximately 1/3rd of that

estimated for indigenous forest. Indigenous forest carbon per ha was estimated within 95% confidence intervals of 3.7%, shrubland within 15%, and areas mapped as indigenous forest and shrubland but with planted exotic trees to within 28%.

Stem total volume over bark averaged 470 m^3/ha (±4% at 95% CI) in indigenous forest, 107 m^3/ha (±18%) in shrubland, and 331 (±35%) in planted exotic trees (Table 11).

Table 11.
Mean per hectare carbon stock by GPG pool, and mean stem volume per ha overall plots and by major vegetation types.

Source	**All types**		**Indigenous forest**		**Shrubland**		**Planted forest**	
	mean	**s.e.**	**Mean**	**s.e.**	**mean**	**s.e.**	**mean**	**s.e.**
AGB (t/ha)	111.2	2.1	140.9	2.7	34.4	2.9	88.5	14.3
BGB (t/ha)	27.8	0.5	35.2	0.7	8.6	0.7	22.1	3.6
CWD (t/ha)	14.8	0.5	18.8	0.5	4.4	0.9	10.9	3.9
FD (t/ha)	19.3	1.6	23.0	2.2	9.7	2.0	15.4	4.4
Overall Total (t/ha)	173.0	3.2	217.9	4.0	57.3	4.3	136.9	19.1
Stem Volume (m^3/ha)	369.3	7.1	469.9	9.0	107.0	9.8	331.3	57.7

The carbon stock of EcoSat types with beech, which comprised the majority of the indigenous forest area, all exceeded 200 t/ha (Table 12). The type with the lowest average carbon (105 t/ha) was unspecified indigenous forest, which included 2 bare ground plots, and 6 shrub plots, but was otherwise largely comprised of forest plots. The subalpine shrubland type included 2 plots with rata and 4 with beech as the major species present, mostly with very high carbon levels, which explains the high average carbon stock per ha for this type and the high variability. The North Island plots had less carbon per ha in broadleaf, podocarp-broadleaf, subalpine shrubland, and unspecified forest types, compared with the South Island, and so the average carbon stock per ha was significantly lower in the North Island than in the South Island. The mapped locations of plots, classified into 5 classes on the basis of total above ground carbon, are shown in Fig. 9.

The precision of national estimates per ha varied markedly amongst types, ranging from 6% in beech, 15% in other shrubland, 18% in broadleaf forest, 31% in podocarp forest, and 48% in subalpine shrubland. There were no plots in Coastal and Podocarp EcoSat Forest types in the North Island.

Estimation error per ha increased when reporting by island, because of the reduction in land area and therefore of the sample size, with for example beech/broadleaf forest estimation error approximately doubling to 68% at 95% CI in the North Island. There was almost no impact on estimation error for beech in the South Island, because 85% of the beech forest nationally occurs there.

Table 12.
Mean carbon stock per ha and standard error by modified EcoSat vegetation type, island and nationally. N is the number of plots comprising the mean.

EcoSat Vegetation class	National			North Island		South Island	
	N	mean	s.e.	mean	s.e.	mean	s.e.
Beech / Broadleaved forest	18	205.3	32.5	197.9	67.0	208.4	36.7
Beech / Podocarp-broadleaved forest	126	266.0	10.6	264.4	22.1	266.5	12.1
Beech forest	330	240.6	7.1	226.1	16.6	243.5	7.8
Broadleaved forest	49	158.6	14.0	119.4	15.0	231.0	28.6
Kauri forest	16	131.2	15.7	131.2	15.7	-	-
Podocarp forest	12	200.7	30.9	-	-	200.6	30.9
Podocarp-broadleaved / Beech forest	117	216.2	11.1	213.9	14.3	219.0	17.5
Podocarp-broadleaved forest	177	210.0	9.7	191.5	12.2	243.1	15.8
Unspecified Indigenous forest	42	105.2	12.5	89.3	15.5	133.1	21.3
Total Indigenous forest	887	217.9	4.0	192.5	6.6	239.3	5.6
Subalpine shrubland	22	113.0	27.2	51.3	27.3	119.9	30.1
Other Shrubland	325	52.4	4.0	70.1	6.9	35.3	4.2
Total Shrubland	347	57.3	4.3	70.0	6.8	42.0	5.1
Planted forest	22	136.9	19.1	140.9	26.9	126.4	24.7
Overall	1256	173.0	3.2	155.4	5.4	184.0	5.1

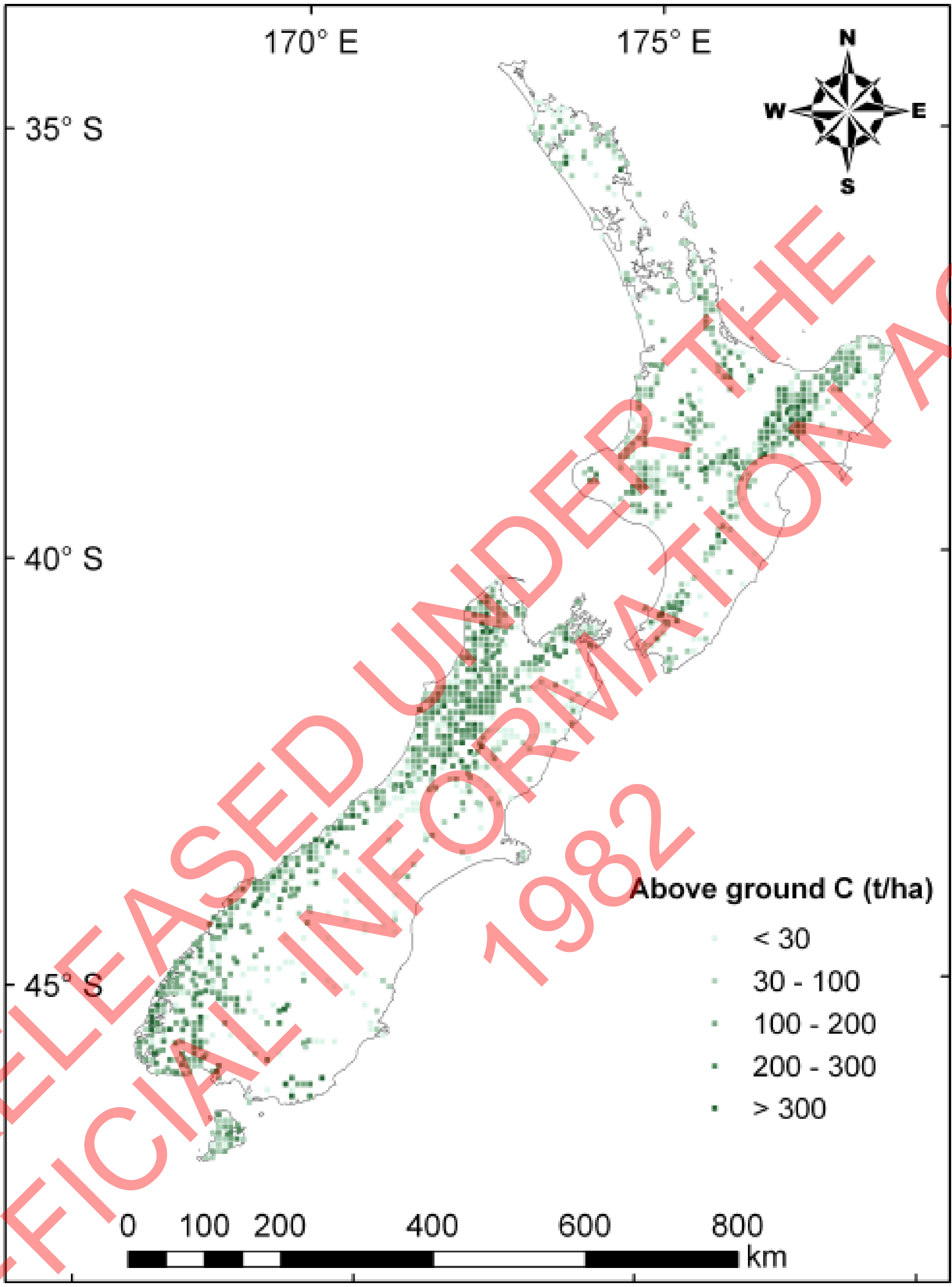

Fig. 9. Location of LUCAS plots classified on the basis of above ground carbon into 5 classes.

3.1.4 National totals for carbon in forest and shrubland and for each of the four GPG carbon pools

National total carbon stocks by GPG pool, summarised by major vegetation types and overall types, are given in Table 13. The forest and shrubland category of LCDB1 contained a total of 1,539 (±56) million tonnes of C, 90% of which was in natural forests as defined by EcoSat, 9% in shrubland, and <1.4% in areas with planted exotic forest as identified by field teams.

These estimates were obtained by treating the LUCAS database as a stratified sample with strata defined by the modified EcoSat classes within each island. Stratified sampling estimates were significantly more precise estimates than simple random sampling estimates. The improvement in precision from stratification is equivalent to an approximately 50% increase in sample size.

The EcoSat area-weighted disposition of total carbon amongst components was 64% in AGB, 16% in BGB, 9% in coarse woody debris (including standing trees and fallen logs >10 cm) and 11% in fine debris (including fallen fine woody debris < 10 cm and forest floor litter, fermenting, and humus layers). The disposition of carbon among these four GPG pools reflects the carbon disposition per ha (Table 11). Indigenous forest carbon stocks estimates have 95% confidence intervals of ±3.7%, while shrubland carbon stocks have confidence intervals of ±15%.

Table 13.

Total carbon stocks (Mt) based on stratified sampling by GPG pool and major vegetation type (Indigenous forest, shrubland, planted).

Source	National		Indigenous forest		Shrubland		Planted forest	
	total	s.e.	Total	s.e.	total	s.e.	total	s.e.
AGB (Mt)	988.6	18.6	892.0	16.8	82.8	7.0	13.8	3.7
BGB (Mt)	247.2	4.7	223.0	4.2	20.7	1.8	3.4	0.9
CWD (Mt)	131.7	4.1	119.3	3.4	10.7	2.1	1.7	0.7
FD (Mt)	171.4	14.5	145.8	13.7	23.4	4.7	2.4	0.8
Total (Mt)	1,539.0	28.1	1,380.1	25.6	137.7	10.3	21.3	5.4

3.1.5 EcoSat total carbon stocks by island

Total carbon stocks are shown for each EcoSat forest type, shrubland, planted exotics, by island, and nationally in Table 14. Summed across indigenous forest types, the South Island/Stewart Is. has almost twice as much carbon as the North Island, while the reverse applies for other shrubland. The overall carbon stock split between South and North islands (62%/38%) therefore largely reflects their respective forest and shrubland areas when all vegetation types are considered. The national total carbon stock in forest and shrubland was 1.539 (±3.6%) million tonnes, with 574 (±7.0%) million tonnes in the North Island and 956 (±5.5%) million tonnes in the South Island/Stewart Is.

Table 14.
Total carbon stock (Mt) in areas mapped as natural forest and shrubland by vegetation type and island.

EcoSat Vegetation class	National		North Island		South Island	
	total	s.e.	total	s.e.	total	s.e.
Beech / Broadleaved	20.2	3.2	5.7	1.9	14.5	2.6
Beech / Podocarp-broadleaved	261.4	10.4	57.7	4.8	203.8	9.2
Beech	526.8	15.4	81.6	6.0	445.2	14.2
Broadleaved	50.8	4.5	24.8	3.1	26.0	3.2
Kauri	11.1	1.3	11.1	1.3	-	-
Podocarp	11.5	1.8	-	-	11.5	1.8
Podocarp-broadleaved / Beech	183.1	9.4	100.3	6.7	82.7	6.6
Podocarp-broadleaved	262.2	12.1	153.2	9.8	108.9	7.1
Unspecified Indigenous	53.1	6.3	28.8	5.0	24.4	3.9
Total Indigenous forest	1,380.1	25.6	479.7	16.4	919.1	21.4
Subalpine scrub	21.9	5.3	1.0	0.5	20.9	5.2
Other Shrubland	115.9	8.9	76.1	7.5	39.7	4.8
Total Shrubland	137.7	10.3	77.4	7.6	54.6	6.6
Planted forest	21.3	5.4	14.0	4.5	7.2	2.9
Total	1,539.0	28.1	574.5	20.1	956.2	26.4

3.1.6 Regional total carbon stocks by GPG pool

The area of forest and shrubland of the LCDB1 that intersects with territorial regions and the total carbon stock by region are shown in Table 15, with Stewart Island grouped with Southland. The region with the greatest total carbon stock is the West Coast followed by Southland/Stewart Is., Bay of Plenty, Tasman and the Waikato, which largely reflects the area of forest within each region. These five regions together contain around 67% of the national total carbon.

Table 15.
Total carbon stock in areas mapped as natural forest and shrubland by region.

Region	N	Area (ha)	Total Carbon (Mt)	s.e.
Auckland	14	114,060	7.5	1.9
Bay of Plenty	94	616,710	124.7	8.8
Canterbury	107	709,663	62.8	7.4
Gisborne	36	247,268	34.8	5.1
Hawkes Bay	44	346,480	67.8	7.1
Marlborough	52	393,965	59.9	7.7
Manawatu – Wanganui	73	604,360	81.2	6.5
Nelson	4	20,242	2.6	0.7
Northland	52	401,395	36.2	4.6
Otago	62	412,072	45.7	6.0
Southland	206	1,423,938	305.4	13.6
Taranaki	40	345,060	56.8	5.3
Tasman	96	609,722	140.9	10.1
Waikato	103	716,164	113.7	9.2
Wellington	40	306,129	50.1	6.0
West Coast	233	1,626,413	344.3	14.9

3.1.7 National carbon stocks by GPG pool for each EcoSat forest class

Carbon stocks per ha by EcoSat forest type and other vegetation types are shown for four GPG pools in Table 16. The disposition by GPG pool and EcoSat type were summarised previously in relation to Tables 13 & 14.

Table 16.
National carbon stocks (t/ha) by GPG pool for each EcoSat forest type, other shrubland, and planted exotic vegetation mapped as indigenous forest and shrubland.

EcoSat Vegetation class	**Total C**		**AGB**		**BGB**		**CWD**		**FD**	
	Total	**s.e.**	**Total**	**s.e.**	**total**	**s.e.**	**Total**	**s.e.**	**Total**	**s.e.**
Beech / Broadleaved	205.3	32.5	140.1	20.3	35.0	5.1	12.6	3.0	17.6	18.8
Beech / Podocarp-broadleaved	266.0	10.6	178.9	7.8	44.7	1.9	20.7	1.3	21.7	3.3
Beech	240.6	7.1	152.0	4.1	38.0	1.0	22.2	1.0	28.5	4.4
Broadleaved	158.6	14.0	105.6	10.3	26.4	2.6	19.1	2.4	7.6	2.3
Kauri	131.2	15.7	89.6	12.6	22.4	3.2	13.3	4.5	5.9	1.1
Podocarp	200.6	30.9	124.8	23.5	31.2	5.9	16.4	2.9	28.2	5.2
Podocarp-broadleaved / Beech	216.2	11.1	140.0	7.6	35.0	1.9	18.7	1.6	22.5	4.9
Podocarp-broadleaved	210.0	9.7	134.5	6.3	33.6	1.6	17.4	1.3	24.4	6.2
Unspecified Indigenous	105.2	12.5	68.7	9.1	17.2	2.3	6.9	1.7	12.4	3.4
Total Indigenous Forest	217.9	4.0	140.9	2.7	35.2	0.7	18.8	0.5	23.0	2.2
Subalpine Shrubland	113.0	27.2	60.8	20.4	15.2	5.1	4.1	1.7	32.8	19.3
Other Shrubland	52.4	4.0	32.1	2.6	8.0	0.7	4.5	0.9	7.7	1.3
Total Shrubland	57.3	4.3	34.4	2.9	8.6	0.7	4.4	0.9	9.7	2.0
Planted forest	136.9	19.1	88.5	14.3	22.1	3.6	10.9	3.9	15.4	4.4
Overall Total	173.0	3.2	111.2	2.1	27.8	0.5	14.8	0.5	19.3	1.6

3.1.8 Carbon in above ground biomass of plots classified on the basis of dominant species composition

Forest classes classified on the basis of the dominant species in each plot are shown mapped in Fig. 10. These classes are named after the most dominant species (either single or multiple when several species are of similar importance). The mean total carbon per ha, and national total stock of each class is given in Table 17, while the carbon contribution of important species in each class is shown in Table 18. Because these classes were derived from the plots, class areas within the total mapped area were not available. Therefore, when estimating the total carbon pools, areas were estimated on the basis of the plot numbers in each class, and standard errors of these calculated based on the binomial distribution.

Included in this classification is a Shrubland class consisting of all plots not measured using the tree measurement method. This mostly consists of plots measured using the shrub biomass method but also includes 27 plots with no woody vegetation, primarily farmland or bare land. This class therefore contains at most only low stature woody vegetation. About 8% of all plots belong to this class which has an average carbon stock of only 4.1 t/ha (Table 17). This class is distributed widely, especially in the South Island.

The most common species composition class with 22% of all plots has Kanuka as its most dominant species, with Manuka and Southern Rata as important secondary species. Kanuka only occurs in the North Island and northern South Island, so in the central and southern South Island and Stewart Island where this class is particularly common, it is dominated by Manuka and/or Southern Rata. Much of this class is probably on highly disturbed sites and likely to be transient in nature, although on some harsh sites, Kanuka/Manuka vegetation can be more or less permanent in nature (Wardle, 1991). This Kanuka class contains relatively low carbon levels averaging 58 t/ha.

Four of the remaining classes are dominated by hardwoods other than beech. The Towai/Northern Rata class is confined to the northern North Island. The Tawa class which contains no other important species and the Kamahi/Tawa class which has strong elements of Rimu and Northern Rata are both largely confined to the central and southern North Island. In contrast, the Kamahi/Hard Beech class is fairly widespread in both islands.

Three classes consist of podocarp/hardwood mixtures. The relatively minor Matai/Rimu/Mahoe is scattered across both islands, while the Kamahi/Rimu class is especially common in the coastal West Coast but also found in the North Island. The most important podocarp/hardwood class is Southern Rata/Kamahi/Rimu which is confined to the South Island and Stewart Island.

The remaining four classes are dominated by beech species and occur at mainly higher altitudes in both islands. The least important is the Black Beech class which is scattered across both islands on dry sites. Mountain/Silver Beech is the dominant class at high altitudes in both islands, while Red/Silver and pure Red Beech classes occur at somewhat lower altitudes.

The classes with the highest levels of carbon, all in excess of 270 t/ha, are those dominated by Red or Red/Silver Beech, and classes with significant Kamahi and Rimu elements, including the Kamahi/Rimu, Southern Rata/Kamahi/Rimu, and Kamahi/Tawa classes. Apart from the Kanuka class which averages 58 t/ha all other forest classes average between 137 and 313 t/ha. The most important class in terms of the national total carbon pool is the Silver/Mountain Beech class followed by the Red/Silver Beech class.

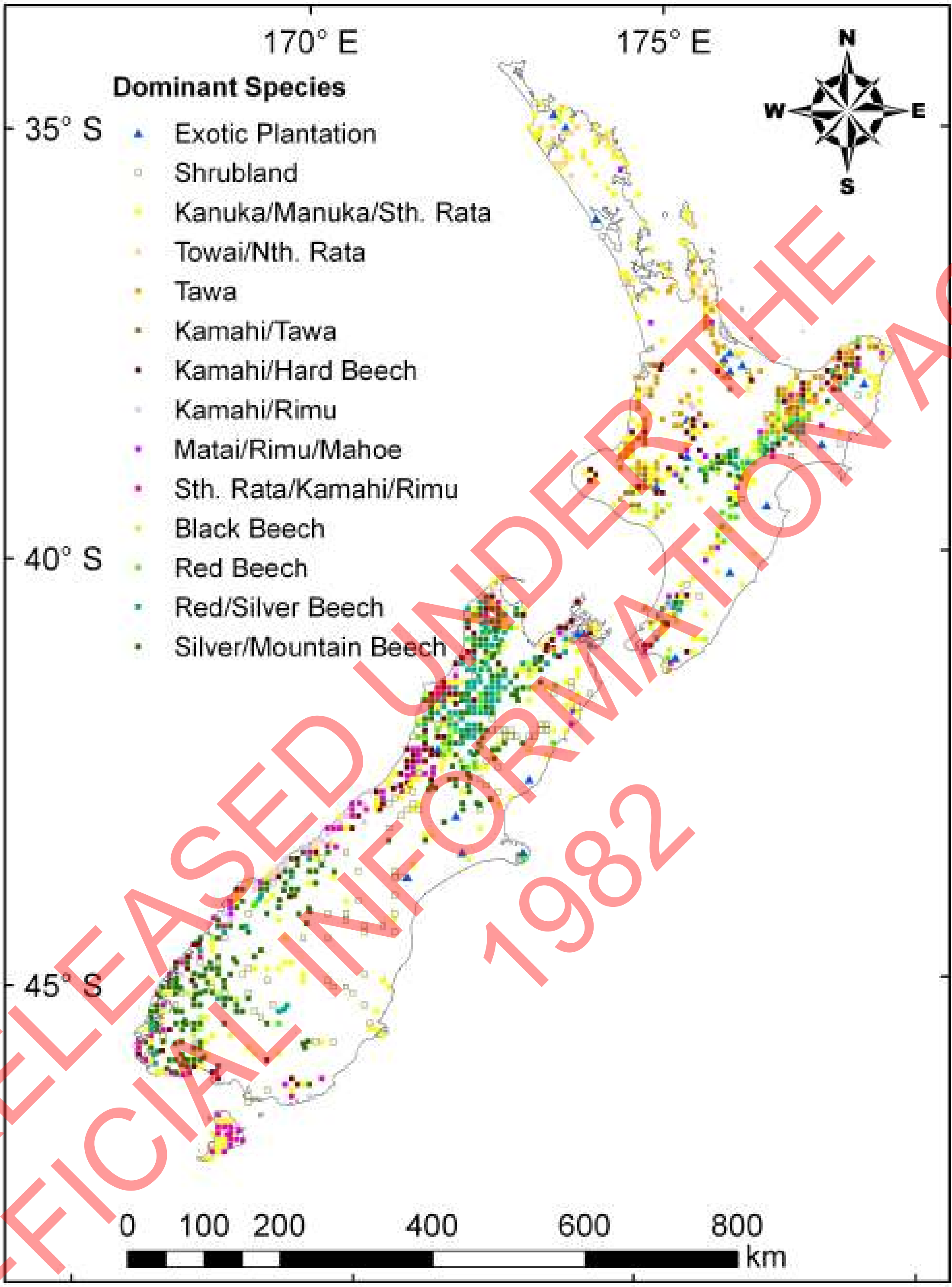

Fig. 10. Location and dominant species composition of LUCAS plots.

Table 17.
Mean total carbon stock (t/ha) and national total pool (Mt) by species composition class. N is the number of plots.

Species Composition	**N**	**Mean (t/ha)**	**s.e.**	**Total (Mt)**	**s.e.**
Exotic Plantation	22	136.9	18.6	21.3	5.4
Shrubland	106	4.1	0.1	3.1	0.3
Kanuka	280	57.8	3.3	114.6	8.9
Towai/Northern Rata	27	144.4	16.6	27.6	6.1
Tawa	96	177.8	8.1	120.9	13.1
Kamahi/Tawa	30	283.8	24.5	60.3	12.1
Kamahi/Hard Beech	118	202.5	6.6	169.2	15.8
Kamahi/Rimu	41	277.1	18.4	80.4	13.5
Matai/Rimu/Mahoe	26	140.0	19.2	25.8	6.1
Southern Rata/Kamahi/Rimu	63	300.1	17.2	133.9	18.1
Black beech	36	220.9	14.3	56.3	9.9
Red Beech	61	293.8	16.0	126.9	17.3
Red/Silver Beech	115	312.8	8.4	254.7	23.6
Silver/Mountain Beech	235	209.7	5.1	348.9	22.2

Table 18.
Mean AGB carbon (t/ha) for important species in each species composition class.

Species	**Species Composition Class**											
	KM	TR	T	KT	KH	KR	MR	RK	BB	RB	RS	SM
W. racemosa	0	0	3	57	47	58	1	36	7	13	21	4
N. fusca	0	0	1	8	1	1	0	2	3	136	91	3
N. menziesii	0	0	0	0	6	9	0	7	14	3	67	69
D. cupressinum	0	2	4	15	1	58	14	33	2	6	1	1
B. tawa	0	1	54	46	1	2	4	0	1	0	0	0
N. solandri	0	0	0	0	0	0	0	1	90	1	1	0
M. umbellata	4	0	0	0	3	0	0	67	4	1	5	3
N. solandri Var. Cliffortioides	0	0	0	0	0	3	0	8	1	1	2	43
M. robusta	0	15	2	32	0	0	0	0	1	0	0	0
P. ferruginea	0	2	3	2	1	19	4	7	2	5	1	0
N. truncata	0	0	1	0	28	4	0	2	0	2	4	1
M. ramiflorus	1	1	9	4	1	1	15	0	0	1	0	0
P. taxifolia	0	0	1	3	0	5	22	0	0	0	0	0
E. dentatus	0	2	4	12	1	3	1	0	0	1	0	0
W. silvicola	0	22	0	0	0	0	0	0	0	0	0	0
P. hallii	0	1	0	0	3	0	0	12	2	2	1	1
D. dacrydioides	0	0	1	0	0	13	5	0	0	0	0	0
K. ericoides	8	3	0	0	1	0	1	0	0	0	0	0
A. australis	0	4	0	0	0	0	7	0	0	0	0	0
A. rosifolia	0	8	0	0	0	0	0	0	0	0	0	0
L. scoparium	4	1	0	0	0	0	0	1	0	0	0	0
Other	17	38	29	19	27	14	25	22	12	18	12	9

Classes are coded as follows: KM:Kanuka/Manuka/SRata, TR:Towai/NthRata, T:Tawa, KT:Kamahi/Tawa, KH:Kamahi/HBeech, KR:Kamahi/Rimu, MR:Matai/Rimu/Mahoe, RK:SRata/Kamahi/Rimu, BB:BlackBeech, RB:RedBeech, RS:Red/SilverBeech, SM:Silver/MountainBeech

3.1.9 Total carbon per species

The species code, scientific name, plant type, total carbon and stem volume, whole stem density, adventive or native, and conifer or broadleaf classification are given for each species in Appendix 3. More detail about each species is contained in a separate spreadsheet.

The twenty most important species in the indigenous forest and shrubland, ranked by volume (of all trees), are shown in Table 19. Kauri contributes negligibly to the national total above ground biomass carbon stock. If ranked in terms of carbon, tree ferns rank lowest in this list because of their lower wood density. These twenty species comprise 87% of the volume and 86% of the above ground biomass carbon stocks nationally. In the 22 exotic plantation plots, 74% of the volume was in pines, 17% in other exotic tree species, and the remaining 9% mainly in indigenous shrubs and ferns.

Table 19.

Mean per hectare stem plus large (>10 cm) branch volume of all trees and trees >10 cm DBH, above ground live mass per ha, above ground live carbon per ha, total volume, and total above ground live carbon of the 20 most important species ranked by stem volume (excludes planted forest plots and data collected using the continuous or discrete shrub methods).

Species	**Volume (m^3/ha)**		**Mass (t/ha)**	**AGB Carbon (t/ha)**	**Total Volume (Mm^3)**	**AGB Carbon (Mt)**
	All trees	**DBH>10cm**	**All trees**			
N. menziesii	72.4	71.1	42.3	21.2	632.8	184.8
N. fusca	58.6	58.3	32.7	16.3	512.3	142.7
W. racemosa	41.7	39.3	26.9	13.5	364.5	117.6
N. solandri Var. *Cliffortioides*	28.5	27.5	18.2	9.1	249.0	79.7
D. cupressinum	19.9	19.9	10.6	5.3	174.3	46.4
B. tawa	17.8	17.4	11.2	5.6	155.8	49.1
M. umbellata	12.3	12.1	11.4	5.7	107.1	49.6
N. truncata	11.9	11.7	7.6	3.8	103.8	33.2
N. solandri	8.7	8.6	5.7	2.9	76.0	25.0
C. smithii	6.6	6.5	0.8	0.4	57.2	3.3
P. ferruginea	6.4	6.3	3.8	1.9	55.9	16.8
K. ericoides	5.2	4.1	4.4	2.2	45.5	19.1
M. ramiflorus	4.9	4.3	2.9	1.4	42.4	12.6
D. squarrosa	4.7	4.2	0.5	0.3	41.0	2.4
G. littoralis	4.5	4.2	3.5	1.7	39.6	15.3
P. hallii	4.2	4.0	2.7	1.4	36.6	11.9
C. dealbata	3.7	3.7	0.4	0.2	32.7	1.9
K. excelsa	3.6	3.5	2.3	1.2	31.8	10.2
M. robusta	3.5	3.5	2.6	1.3	30.6	11.2
D. dacrydioides	3.4	3.4	1.5	0.7	30.0	6.5
All Other Species	48.7	39.7	31.6	15.8	425.3	138.2

3.1.10 National estimates of carbon and standing volume from the live stem data for various species groupings

The mean volume, mass, AGB carbon per ha, and the national totals of volume and AGB carbon based on LUCAS plots are shown in Table 20. Broadleaf species comprise 85-90% of the stem volume and carbon stocks, with most of the remaining carbon occurring in coniferous species, while native canopy and subcanopy trees contain 96% of the carbon stock nationally.

Approximately 38% of the stem volume and carbon stocks nationally are in trees >50cm DBH, with approximately 70% in trees >30 cm DBH. LUCAS used a 20 m radius plot to assess trees ≥ 60 cm DBH, so the total area of forest and shrubland directly measured nationally in plots was 160 ha (1.7% of total area) for trees and CWD ≥ 60cm diameter, and 50 ha (0.6% of the total area) for the remainder. The precision of the carbon stock estimate was significantly improved using the large plots, although accuracy was reduced because a significant proportion of the large trees were missed by field teams. This topic needs to be re-examined after the plot network has been re-measured and the missing stems included.

Table 20.

Mean per hectare stem volume and above ground live mass and above ground live carbon of various tree and shrub types and size classes within the indigenous forest & shrubland LCDB1 area (excludes planted forest plots and data collected using the continuous or discrete shrub methods), and area weighted total volume and carbon stocks.

Classification	Volume (m^3/ha)	Mass (t/ha)	AGB Carbon (t/ha)	Total Volume (Mm^3)	AGB Carbon (Mt)
Tree type					
Broadleaf	309.0	196.2	98.1	2700.1	857.0
Conifer	43.5	24.7	12.4	380.2	108.1
Unknown	1.1	0.7	0.4	9.5	3.1
Other	17.8	2.3	1.1	155.8	9.9
Species Origin					
Native	368.9	222.3	111.2	3223.5	971.4
Adventive	1.4	0.8	0.4	12.6	3.6
Unknown	1.1	0.7	0.4	9.5	3.1
Plant form					
Canopy tree	309.7	189.9	94.9	2706.4	829.5
Subcanopy tree	35.2	25.4	12.7	307.3	111.0
Shrub	7.2	5.4	2.7	63.3	23.6
Tree fern	17.4	2.0	1.0	152.0	8.8
Other	1.9	1.2	0.6	16.6	5.1
DBH Class (cm)					
0-10	17.4	13.2	6.6	152.4	57.7
10-30	96.0	55.5	27.8	839.0	242.6
30-60	118.3	72.8	36.4	1034.0	318.0
60-100	83.5	49.1	24.5	729.5	214.4
>100	56.2	33.3	16.6	490.7	145.4
Total	371.4	223.9	111.9	3245.6	978.1

3.1.11 Comparison with previous volume and carbon stock estimates

Table 6 in Coomes et al. (2002) gives carbon stock estimates across a 60 km-wide transect across the South island of New Zealand, which was a pilot study undertaken to test plot installation and measurement procedures to be used by LUCAS and to document methods for calculating carbon stocks in the live and dead carbon pools using such data. In forest plots along the South Island transect live biomass carbon averaged 169.1 t/ha (cf. 176.1 t/ha which includes AGB of 140.9 and BGB of 35.2 t/ha in LUCAS plots, Table 11), CWD averaged 29.6 t/ha (cf. 18.8 t/ha), and fine debris averaged 15.5 t/ha (cf. 23.0 t/ha), while in shrub plots above ground biomass carbon averaged 48.6 t/ha (cf. 43.0 t/ha), CWD averaged 5.2 t/ha (cf. 4.4 t/ha) and fine debris averaged 8.9 t/ha (cf. 9.7 t/ha). Fine debris (FD) was the most variable pool based on LUCAS plots (Table 11), primarily due to variation in the humus fraction (Garrett 2009), though less variability was evident in the fine litter pool along the South Island transect, possibly because the sample size was small and the variability may therefore have been underestimated.

National totals of stem volume and carbon for the twenty most common species based on 1st year LUCAS NVS plots (Peltzer and Payton 2006) are broadly similar in terms of species ranking and amounts to those found using the full set of LUCAS NVS plots. Of the top twenty species in Peltzer and Payton (2006), neither *Ixerba brexioides* nor *Quintinia serrata* featured in the top 20 list based on the full set of LUCAS plots, where *Cyathea dealbata* and *Metrosideros robusta* featured instead.

National estimates of above ground biomass carbon based on 1st year LUCAS plots (Table 5 in Peltzer and Payton 2006) were 152 t/ha (n = 202 plots) for indigenous forest and 9 t/ha (n = 42 plots) for shrubland, using the field team classifications of cover. Their results can be compared with estimates given in Table 11 which are based on the full set of LUCAS plots - 141 t/ha (n = 887) for above ground biomass carbon in indigenous forest and 34.4 t/ha for shrubland (n = 347), respectively, which were classified using EcoSat forest and shrubland types. Differences between studies will be due to differences in the allometric functions (as documented in Beets et al, 2008b), wood density estimates by species (in Appendix 3 of this report compared with Appendix A in Peltzer and Payton 2006), and sample size (first year plots versus 5 year plots), and plot classification method.

Stem volume estimates for indigenous forest (16.0 m^3/ha) and shrubland (0.71 m^3/ha) given in Table 5 of Peltzer and Payton (2006) have clearly not been reported correctly. There are 470 m^3/ha and 107 m^3/ha of stem total volume in indigenous forest and shrubland, respectively (Table 11).

3.2 CARBON STOCK CHANGE IN NATURAL FORESTS (BY REGION, SPECIES AND FOREST TYPE)

Carbon stocks at the NVS and LUCAS measurements for above ground biomass and CWD pools for each plot are given in Appendix 4. Carbon stock changes reflect above ground biomass growth (of persistent trees and ingrowth) and tree mortality. Growth of persistent trees reflects the increases in their DBH and height, while ingrowth reflects new trees appearing for the first time because the stem diameter attained at least 2.5 cm at breast height. Mortality is associated with the transfer of carbon from the live organic matter pool to the dead organic matter pool. While a large proportion of the plot above ground carbon can be lost owing to tree mortality, the impact on the total carbon stock is initially minimal, because there is a commensurate increase in carbon in the dead pool. Over time, the overall loss of carbon depends on the rate of tree growth and on the decay rate of the debris.

3.2.1 Change (and % change) in AGB carbon (partitioned into tree growth, mortality and recruitment) on the re-measured NVS plots

The annual changes in above ground carbon stocks in forest plots since 1990 associated with ingrowth, growth of persistent trees, mortality, and coarse woody debris decay are given in Table 21, which includes all above ground carbon pools except the FWD and forest floor LFH(O) pools for which change could not be estimated. Based on NVS plots with suitable growth data (151) the sum of ingrowth and growth (1.44 t/ha/year) slightly exceeded mortality (-1.28 t/ha/year) so that there was a net gain in above ground biomass of 0.17t/ha/year. The CWD pool increased by 0.35 t/ha/year, and therefore the carbon stock in the above ground live and dead pools combined increased by 0.51 t/ha/year (excluding FWD and forest floor LFH(O) pools).

The contribution of tree ferns to these estimates was negligible, with tree ferns contributing approximately 0.01 t/ha/year to the carbon stock change to each of the following - ingrowth, total AGB, and total AG (Table 21). The inconsistent measurement of tree ferns in NVS plots has not therefore unduly affected the estimates of carbon stock changes nationally. The breakdown of stock changes by island (Table 21) shows that the above ground carbon stock in the live and dead pools increased by 0.34 t/ha/year in the North Island and by 0.56 t/ha/year in the South Island.

Table 21.

Mean and standard error of annual change in above ground C (t/ha/yr) by source, based on data from 151 plots with at least 10 years between assessments. Estimates are given for all species and excluding tree ferns, and for North and South Islands.

	Total (n=151)		**Total excluding tree ferns (n=151)**		**North Island (n=42)**		**South Island (n=109)**	
Carbon Source	**Mean**	**s.e.**	**Mean**	**s.e.**	**Mean**	**s.e.**	**Mean**	**s.e.**
Ingrowth	0.127	0.018	0.119	0.018	0.161	0.025	0.114	0.023
Growth	1.315	0.085	1.315	0.084	1.222	0.135	1.351	0.105
Mortality	-1.274	0.158	-1.276	0.158	-1.571	0.313	-1.160	0.183
AGB	0.168	0.182	0.158	0.183	-0.188	0.360	0.306	0.211
CWD	0.345	0.114	0.345	0.114	0.587	0.293	0.251	0.110
Total AG	0.513	0.116	0.505	0.116	0.398	0.224	0.557	0.137

The distribution of carbon stock changes due to growth of persistent trees and ingrowth are shown in Fig. 11. Ingrowth contributed less than 0.5 t/ha/year to total growth in the majority of plots, with persistent trees contributing most to carbon stock gains. Carbon gains from persistent tree growth plus ingrowth ranged from 0.5-2 t/ha/year for 75% of the plots, with the overall mean growth of persistent trees averaging 1.3 t/ha/year.

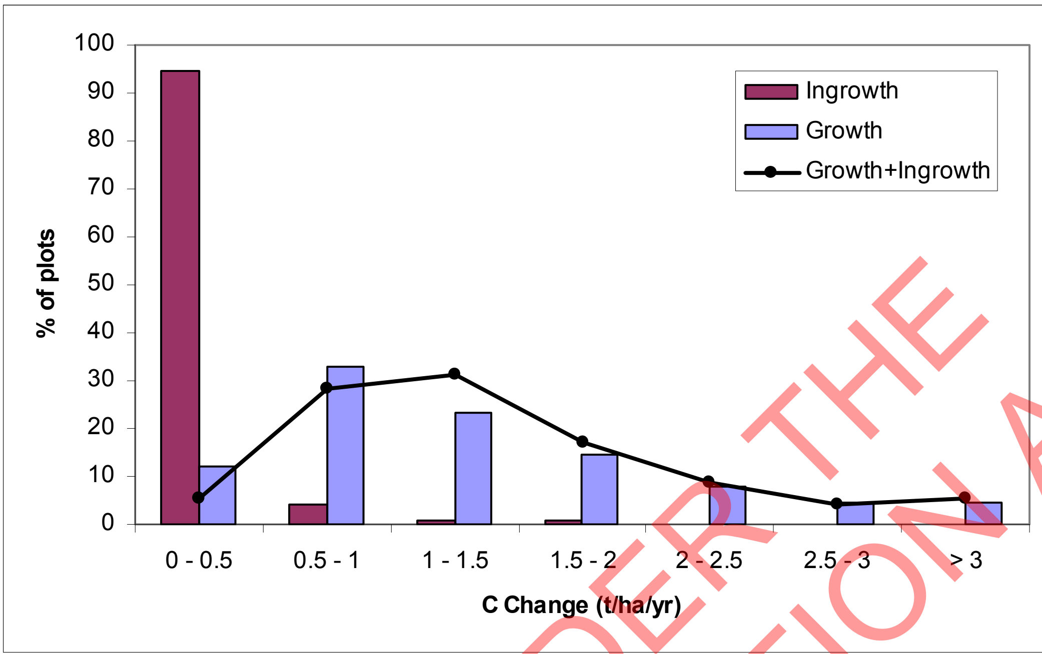

Fig.11. Distribution of annual carbon stock change arising from growth of persistent trees, ingrowth, and total growth based on 151 NVS plots averaged over the period from 1984 – 2004.

The combined effects of growth and mortality on carbon sequestration in above ground biomass is shown in Fig. 12. Mortality ranged between 0-2 t/ha/year in 81% of plots, although a small number of plots showed levels exceeding 5 t/ha/year. The net effect of mortality and growth on carbon change averaged close to zero, and ranged between -2 and 2 t/ha/year in 80% of plots.

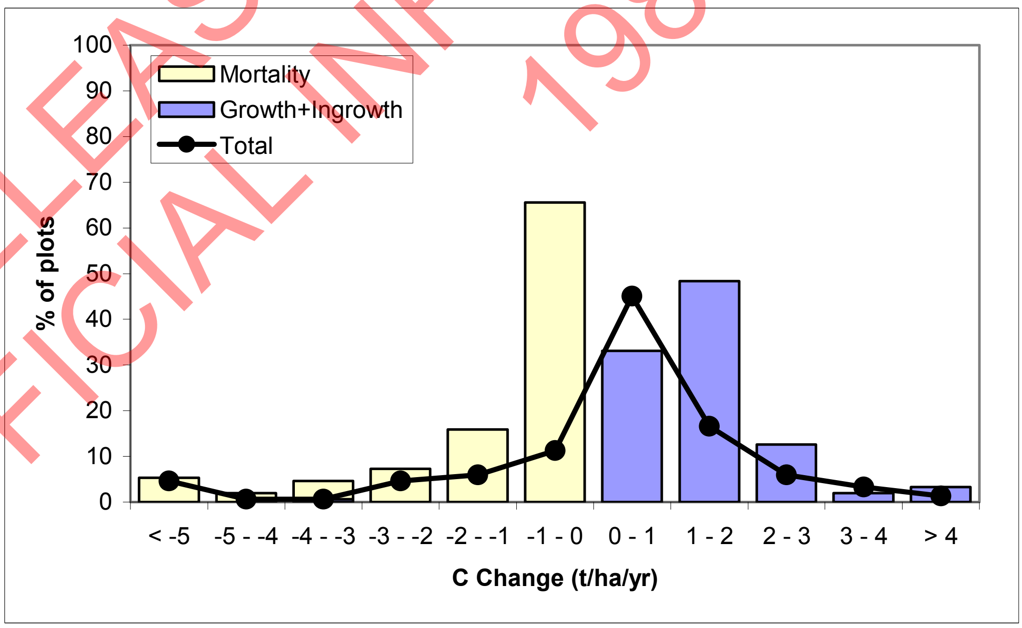

Fig. 12. Distribution of annual carbon stock change arising from total growth and mortality, and net carbon stock change based on 151 NVS plots averaged over the period from 1984 – 2004.

Results of an analysis of carbon stock changes by island and by EcoSat forest type are shown in Table 22. Carbon change did not differ significantly between the North and South Islands (Table 24), which is not surprising because of the limited sample size (n=151). Because of the small number of plots, carbon stock change estimates had relatively large standard errors. Unadjusted EcoSat forest class effects on cnange in total AG carbon were barely significant with a P-value of 0.045 (Table 24). While above ground biomass carbon and above ground total carbon increased in most EcoSat forest types, there was a decrease for broadleaf (both in AGB and Total AG) and podocarp-broadleaf (AGB only) forest types. Forest classes based on species composition showed significant differences in mortality and AGB change (Table 23, Table 24) but these were entirely due to higher levels of mortality in the Kanuka/Manuka class, with the other classes not differing significantly. The higher Kanuka/Manuka mortality may reflect the successional stage of the small number of NVS plots representing this class rather than being a true indicator of the nationwide status for this forest type. No significant differences in carbon change were detected between regions (Table 24). Annual change in AGB carbon is shown mapped in Fig. 13. Overall, the limited sample size of NVS plots allowed reasonable national estimates of stock change, but inadequate estimates within specific forest types or regions.

Table 22.
Estimated mean annual changes in AGB and AG carbon (t/ha/yr) in NVS plots by island and by EcoSat forest class.

EcoSat class	No. plots	AGB		Total AG	
		Mean	s.e.	Mean	s.e.
All New Zealand	151	0.168	0.182	0.513	0.116
North Island	42	-0.188	0.360	0.399	0.224
South Island	109	0.305	0.211	0.557	0.137
Beech / Broadleaved forest	5	0.105	0.668	0.451	0.336
Beech / Podocarp-broadleaved forest	22	0.844	0.406	0.853	0.378
Beech forest	81	0.185	0.238	0.552	0.131
Broadleaved forest	7	-1.325	1.213	-0.343	0.786
Kauri forest	0	-		-	
Podocarp forest	0	-		-	
Podocarp-broadleaved / Beech forest	14	0.633	0.671	0.958	0.362
Podocarp-broadleaved forest	12	-0.598	0.725	0.229	0.314
Unspecified Indigenous forest	1	2.097	-	2.527	-

Table 23.
Estimated mean annual changes in AGB and AG carbon (t/ha/yr) in NVS plots by species composition.

Forest type based on species composition	**No. plots**	**AGB**		**Total AG**	
		mean	**s.e.**	**mean**	**s.e.**
Kanuka/Manuka	6	-3.216	1.488	-1.031	0.855
Kamahi	16	0.788	0.604	0.967	0.406
Kamahi/Rimu/Miro	5	0.723	0.176	0.670	0.222
Kamahi/Tawa	2	-0.546	0.419	1.045	0.329
Mahoe/Matai/Rimu	3	1.375	0.368	1.541	0.503
Southern rata/Kamahi/Rimu	7	0.816	0.201	0.571	0.269
Tawa	7	-0.561	1.063	-0.660	0.871
Towai	0				
Black beech	5	0.699	0.209	0.847	0.166
Red Beech	10	-0.040	1.411	0.688	0.695
Red/Silver Beech	27	0.177	0.446	0.444	0.309
Silver/Mountain Beech	63	0.250	0.187	0.565	0.128

Table 24.
P-values showing statistical significance of differences in carbon change and 1990 pools between forest class, islands (NI vs SI), regions, and species composition classes before and after adjusting for 2004 AGB and CWD pools. Values in bold type indicate statistically significant differences.

Source	**Form**	**Increase in Live Trees**	**Loss due to Mortality**	**Change in AGB**	**Change in CWD**	**Change in total AG**	**1990 AGB**	**1990 total AG**
Forest type	Unadj.	0.59	0.55	0.27	0.74	**0.045**	0.28	0.41
	Adj.	0.83	0.76	0.86	0.74	0.89	0.86	0.89
Island	Unadj.	0.66	0.25	0.23	0.19	0.55	**0.021**	**0.029**
	Adj.	0.77	0.56	0.73	0.42	0.67	0.73	0.67
Region	Unadj.	0.56	0.099	0.10	0.054	0.66	**0.0038**	**0.0009**
	Adj.	0.83	0.10	0.14	0.14	0.52	0.14	0.52
Species Composition	Unadj.	0.39	**0.024**	**0.047**	0.11	0.10	**0.0099**	**0.0069**
	Adj.	0.46	0.15	0.29	0.17	0.46	0.29	0.46

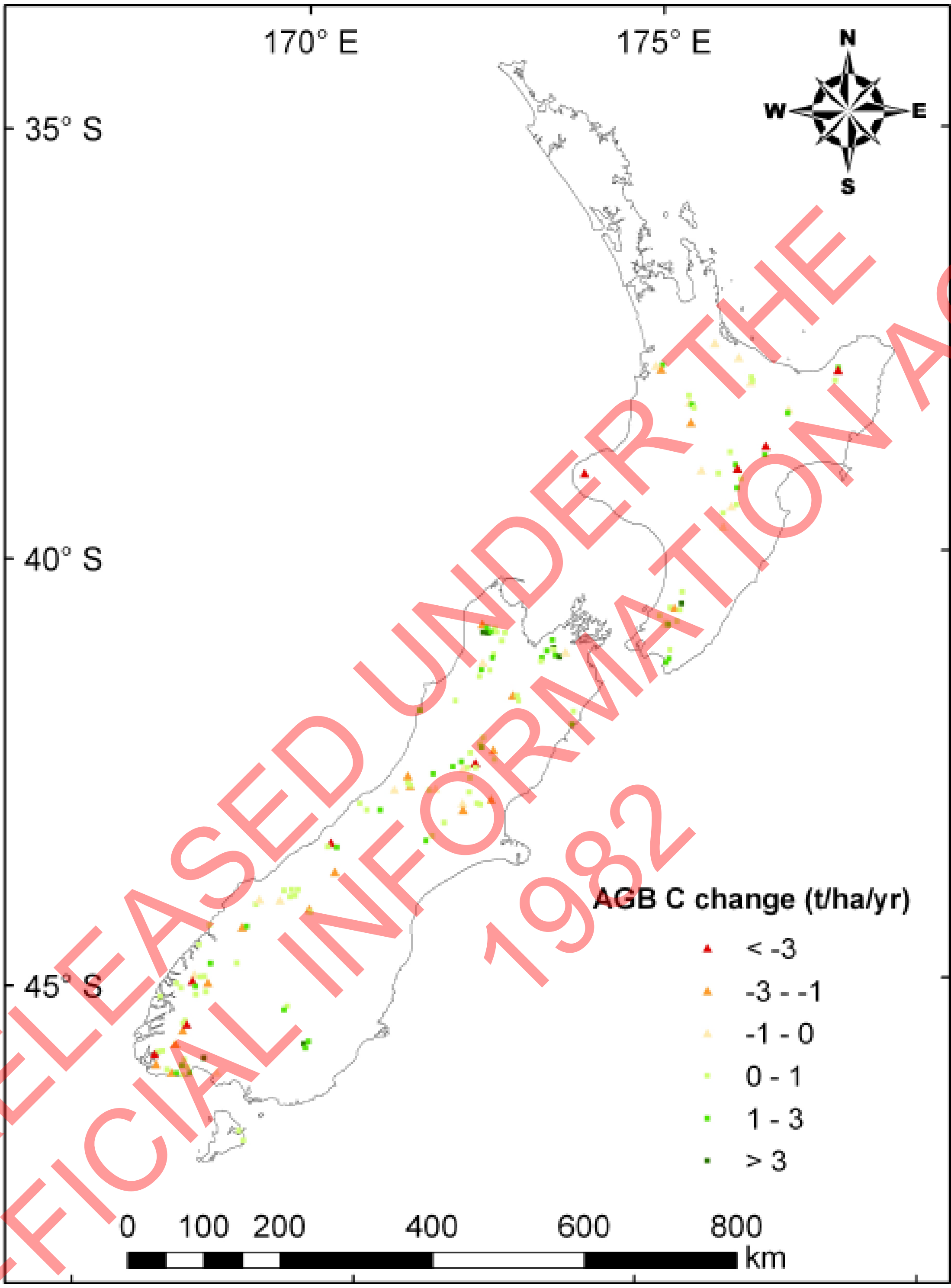

Fig. 13. Location of NVS plots classified on the basis of mean annual change in AGB into 6 classes.

Possum susceptible species showed a reduction in the above ground biomass carbon pool, with carbon losses due to tree mortality exceeding carbon gains due to growth. This result for possum-preferred species contrasts with the result obtained for all other species, in which growth exceeded mortality (Table 25).

Possum preferred species are mostly comprised of hardwood trees other than beech species, and include the following species in the top 20 species list - *Metrosideros umbellata*, *M. robusta*, *Weinmania racemosa*, *Melicytus ramiflorus*, and *Kunzea ericoides,* and the softwood, *Podocarpus hallii*. Possum preferred species as a group comprise approximately 20% of the above ground live tree carbon pool, and therefore it is appropriate to compare their growth and mortality as a percentage of their respective totals, as shown in the lower half of Table 25. Compared with all other species, possum preferred species have a similar growth (from ingrowth and persistent trees) but significantly more mortality in an analysis across the 151 suitable NVS plots nationally.

Table 25.

Mean annual change in AGB carbon by source for 39 possum preferred species and all other species, based on data from 151 plots with at least 10 years between assessments.

	Possum preferred species		**All other species**	
Carbon Source	**Mean (t/ha/yr)**	**s.e. (t/ha/yr)**	**Mean (t/ha/yr)**	**s.e. (t/ha/yr)**
Ingrowth	0.033	0.006	0.103	0.017
Growth	0.239	0.034	1.140	0.085
Mortality	-0.410	0.107	-0.972	0.141
Total AGB	-0.138	0.109	0.270	0.161
	Mean (%/yr)	**s.e. (%/yr)**	**Mean (%/yr)**	**s.e. (%/yr)**
Ingrowth	0.10	0.02	0.08	0.01
Growth	0.71	0.10	0.84	0.06
Mortality	-1.23	0.32	-0.72	0.10
Total AGB	-0.41	0.33	0.20	0.12

3.2.2 Comparison with previous carbon stock change estimates

Peltzer and Payton (2006, Table 9) found a reduction in carbon stocks over time of 0.5 t/ha/year owing to carbon losses from mortality (-2.86 t/ha/year) exceeding carbon gains due to growth of persistent trees (1.13 t/ha/year) and ingrowth (1.22 t/ha/year). They attributed this reduction to a subset of disturbed plots, with no consistent trend otherwise evident at the plot level in an analysis of 39 1st year NVS plots within LUCAS. The corresponding carbon stock changes in our analysis of 151 NVS plots is 0.13 t/ha/year for ingrowth, 1.32 t/ha/year for growth of persistent trees, and -1.28 for mortality, with an overall increase in the above ground biomass carbon stock of 0.17 t/ha/year.

Ingrowth and mortality estimates obviously differ between the two analyses. Fig. 11 indicates that 95% of plots have ingrowth in the range 0-0.5 t/ha/year, while Fig. 12 indicates that 80% of plots have mortality in the range 0-2 t/ha/year. These findings suggest that the analysis in Peltzer and Payton (2008) of 1st year ingrowth and mortality was over-estimated due to miss-matched trees. When trees are not matched accurately, estimates of both ingrowth and mortality will inevitably be too high. In our analysis we excluded plots where tree matching was not possible.

Above ground carbon stocks in both live and dead pools increased by 0.51 t/ha/year, based on our analysis of 151 NVS plots. Concomitant stock changes in both live and dead carbon pools were not estimated by Peltzer and Payton (2006).

Hall (2008) showed above ground biomass carbon stocks decreased in possum-preferred species in an analysis of NVS plots installed throughout NZ. The relatively small set of NVS plots incorporated as part of LUCAS reflects the trend evident in the large set of NVS plots examined by Hall (2008). The LUCAS plot network provides an unbiased estimate of carbon stocks in NZ's indigenous forest and shrubland, and re-measurement of this network can be expected to detect stock changes in both the live and dead carbon pools by forest type and island.

3.2.3 Carbon stock change in natural forest (whether forests are a source or sink of carbon) by forest type and nationally and uncertainty of estimates

Analysis of the NVS data showed that carbon stock change in AGB and total above ground carbon were both positively related to the AGB pool in the LUCAS year and negatively related to the CWD carbon pool, as shown by Functions 2 and 4 in Table 26. This indicates that positive stock changes tend to have occurred in plots with high levels of living biomass and negative stock changes tend to have occurred in plots with high levels of CWD, which indicate high levels of recent mortality. AGB and especially the total AG carbon stocks in 1990 are both positively related to the live and dead stock in 2004. This simply reflects the fact that trees that occurred in 1990 are either in the live tree pool or dead pool in 2004, although they may have grown somewhat or decayed in the case of trees that died. These relationships are illustrated by Figs. 14 and 15 which show strong relationships between 1990 pools and AGB in 2004, and also indicate that the relationships depend on the amount of 2004 CWD pool.

As shown earlier, a number of significant regional and forest type differences were found between the 1990 and 2004 carbon pools and pool changes. However, when the 2004 AGB and CWD pools were included as covariates in this analysis, these significant differences disappeared (Table 24). This implies that the regression models given in Table 26 adequately account for forest type and regional differences, and give confidence that estimates obtained by applying these models to the complete set of LUCAS plots are likely to provide a fair nationwide representation of the 1990 pool and of carbon change between 1990 and 2004.

Table 26.

Regression equations relating annual change in carbon and 1990 pools to 2004 AGB and CWD carbon pools. For each equation, the coefficients (with standard errors in parentheses) and the R^2 are given. Statistically significant coefficients are in bold type.

Source	**1990 AGB (t/ha)**	**Total change in AGB (t/ha/yr)**	**1990 total AG (t/ha)**	**Change in total AG (t/ha/yr)**
	Fn 1	**Fn 2**	**Fn 3**	**Fn 4**
Intercept	0.0 (4.8)	0.00 (0.34)	**-10.6 (2.6)**	**0.76 (0.19)**
2004 AGB	**0.910 (0.023)**	**0.00645 (0.00162)**	**0.953 (0.013)**	**0.00333 (0.00090)**
2004 CWD	**0.516 (0.073)**	**-0.0368 (0.0052)**	**1.448 (0.040)**	**-0.0320 (0.0029)**
R^2	0.92	0.30	0.98	0.48

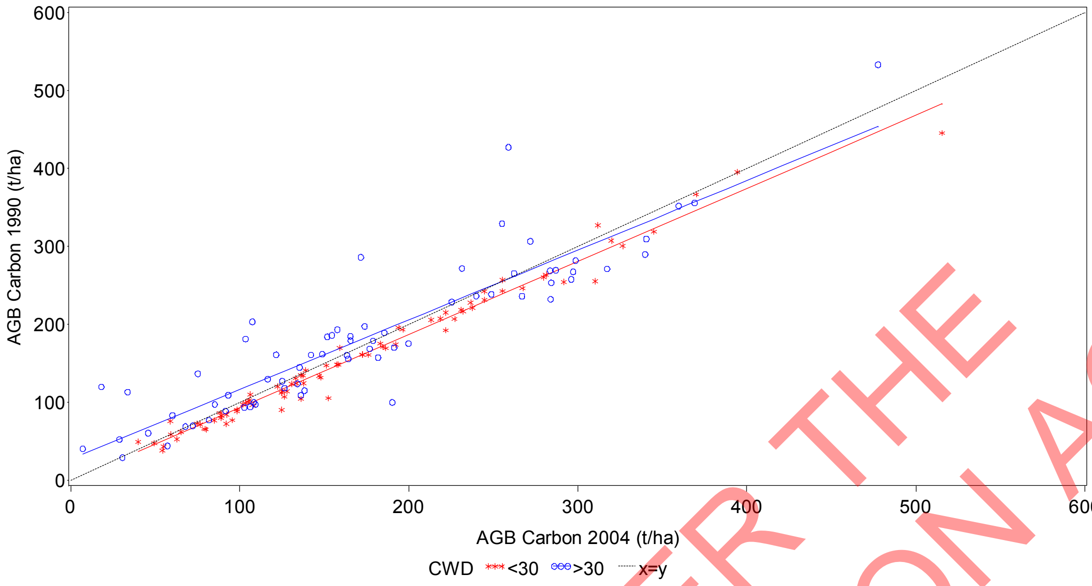

Fig. 14. Above ground biomass carbon stock in plots in 1990 versus stock in 2004 for plots with <30 t/ha (triangles) and plots with >30 t/ha of CWD (circles).

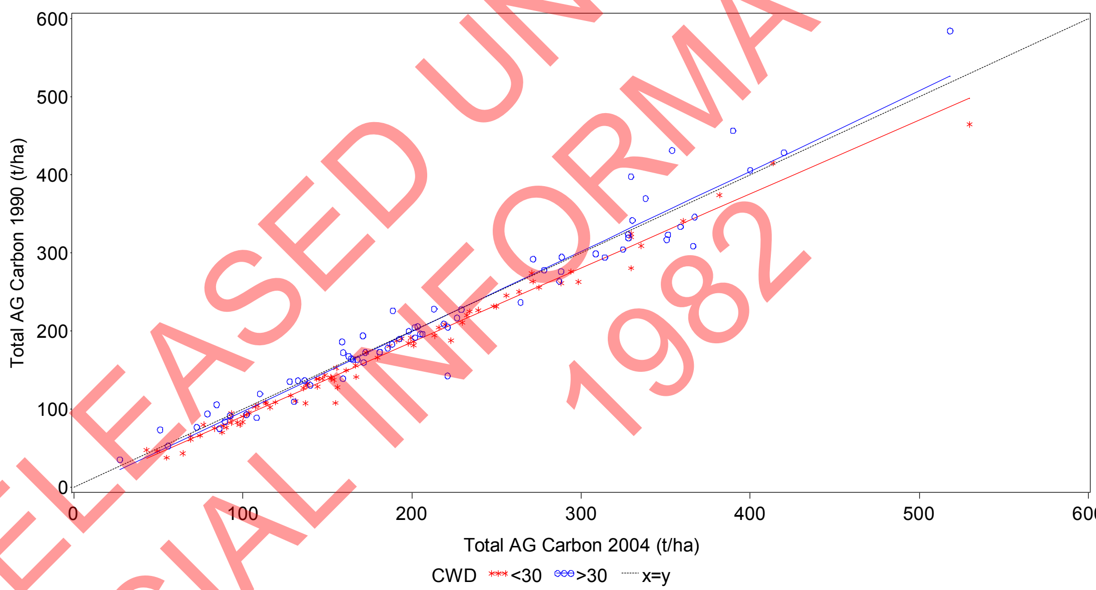

Fig. 15. Above ground biomass plus CWD carbon stock in plots in 1990 versus stock in 2004 for plots with <30 t/ha (triangles) and plots with >30 t/ha of CWD (circles).

The regression models (Table 26) were therefore used to improve the estimates of 1990 stocks and 1990-2004 stock changes obtained from the NVS plots using the additional information from the full set of LUCAS plots (Table 27). The NVS plots had higher average stocks than the full set of LUCAS plots, but the regression estimated stock changes based on the full set of plots are slightly higher than those obtained directly from the NVS plots (Table 27).

Table 27.

Estimated AGB and total above ground C in 1990 and 2004 C pools and its difference for indigenous forest (t/ha).

Source	**Year**	**C/ha estimates from NVS plots**		**National stock and change regression estimates (t/ha)**			**National stock and change regression estimates (Mt)**	
		Estimate	s.e.	Fn	Estimate	s.e.	Estimate	s.e.
AGB	2004	171.6	7.7		143.1	2.8	906.2	17.9
	1990	169.3	7.5	1	140.1	3.8	887.4	23.9
	1990-2004	2.3	2.6	2	3.0	2.2	18.8	14.1
Total AG	2004	197.1	8.1		162.4	3.0	1,028.4	19.2
	1990	189.9	8.3	3	153.8	3.8	973.9	24.0
	1990-2004	7.2	1.6	4	8.6	1.3	54.6	8.1

The results in Table 27 suggest that carbon stocks in New Zealand indigenous forests have remained unchanged in terms of above ground biomass or increased slightly in terms of the combined above ground biomass plus coarse woody debris carbon pools since 1990. Using the means and standard errors in Table 27, 95% confidence intervals for the 1990-2004 percentage change in AGB carbon are 1.4±3.0% (NVS plots) or 2.0±3.1% (regression estimators using LUCAS plots). This implies that at worst, AGB declined by 1% but it may have increased by as much as 5%. For total above ground carbon including both live and dead coarse woody debris the picture is even more positive, with a percentage change of 3.8±1.7% (NVS plots) or 5.6±1.6% (LUCAS plots) implying that above ground carbon increased by between 2% and 7%.

It should be noted that all standard errors tabulated in this study, and 95% confidence intervals derived from them, are based purely on plot-to-plot variation in carbon pool or pool change estimates. They take no account of errors in the models used to derive the carbon estimates for each plot. Therefore, for a full appreciation of the likely reliability of these carbon change estimates, it is necessary to consider in some detail how they are derived.

Change in AGB is calculated using tree dimension measurements taken at two times for each plot. The same allometric models and wood density tables were used for estimating carbon for each measurement. Therefore, even if these models are biased, the bias will affect each estimate equally, and the percentage change will not be affected. Therefore, the above confidence intervals for percentage change in AGB carbon provide a fair indication of their reliability.

However, for change in total above ground carbon, the picture is more complex. Total carbon change was calculated by combining the change in above ground biomass and the change in CWD. Unlike biomass change, CWD change was not calculated as the difference between two measurements. Instead, a base-line CWD pool was estimated using LUCAS CWD measurements. Then the change over the preceding period was estimated by adding the input from mortality and subtracting the loss due to decay. The annual input from mortality, μ, calculated from NVS data was 0.858 t/ha/yr (s.e. 0.104). Note that this excludes stems < 10 cm DBH, branches and foliage and is therefore less than the total mortality given in Table 21. Decay rate was predicted using the exponential decay model described in Beets et al. (2008a). For a CWD pool of C (t/ha) this model predicts the rate of decay to be λC, where λ the decay constant equals 0.0229. When the input from mortality matches the loss from decay, the CWD pool will be in equilibrium. It can easily be shown that this occurs when the CWD pool is $-\mu/\lambda$. For the NVS data, this equilibrium level is therefore 0.858/0.0229 = 37.5 t/ha. It is because this equilibrium level is 50% greater than the measured NVS CWD pool of 25.4 t/ha that the CWD is predicted to have increased between 1990 and 2004.

Assuming the above values for the decay rate and the CWD pool are correct, the implication is that mortality over the past 20 years has been about 50% higher than its longer-term average. However, before we accept this, it we should consider the other possibilities. These are that either the decay constant λ used in the analysis is 50% higher than its true value, or that the true CWD pool is 50% higher than our estimate, or that both are in error to a lesser extent. This study uses a single average value for the decay constant, which is certainly an approximation as Beets et al. (2008a) suggest that it varies with piece diameter and air temperature. Also, there is no doubt that the CWD carbon pool is much less accurately estimated than the live pool because of difficulties in estimating volumes of dead logs, the need for using decay modifiers, and because the species and therefore original wood densities are often unknown. However, despite these shortcomings, it seems unlikely that either the decay rate or CWD values used in our analysis are in error by as much as 50%. One other possibility, although also unlikely, is that the decay function is radically different from exponential. For example, if we assume a linear decay function with the same half life established by Beets et al. (2008a) of $t_{1/2}$ = 30 years, the equilibrium CWD is $\mu \times t_{1/2}$ = 25.7 t/ha, very similar to the measured value.

Given the difficulties of estimating CWD carbon change used in this study, it might appear that direct measurement of CWD carbon at two different times (which would be possible after plot re-measurement), should provide a better estimate of CWD change. However, because of the subjective nature of current methods of assessing CWD, we believe this direct difference method is probably even more prone to error. Based on current knowledge about the components in terms of the natural variability, and the data available, and their impacts on stock change as indicated in Table 26, the ranking of components for improving estimation methods in decreasing order of priority is: decay constants, wood densities, decay class modifiers, and component volumes. This ranking will also depend somewhat on the future approach adopted for monitoring stock changes in the dead components. For example, using decay functions would reduce the future need for decay class modifiers but would require a better understanding of species and environmental differences in decay rates, and the nature of the decay function.

In summary, we can say with certainty that above ground biomass carbon in the national indigenous forest estate remained approximately stable between 1990 and 2004, with the rate of mortality being matched by growth and ingrowth. Although somewhat more uncertain, there is also a strong indication that mortality over the period was higher than its long-term average. It is possible that both the mortality rate and the average tree growth rate have increased, as they have clearly been in balance over the last 20 years. There is also evidence that increased mortality over the period has caused an accumulation of CWD leading to an increase in total above ground carbon over the period.

3.2.4 DBH growth trajectories of live trees by species, and plot location

The periodic mean annual increase (PAI) in DBH based on measurement intervals less than 10 years, 10-20 years, and greater than 20 is shown in Table 28. This shows that the variation in DBH increment as indicated by the standard deviation was twice as great in plots assessed over a measurement interval of less than 10 years compared with those assessed over a longer period. Also, over short time intervals, an appreciable number of trees show a negative DBH increment. For example, for trees measured over less than 10 years, 5% have increments less than -0.075 cm/yr. This reflects the difficulty in measuring DBH sufficiently accurately to detect a change over a short period of time. On the other hand, relocating plots and individuals trees will become increasingly difficult over longer time intervals. Despite considerable efforts, a number of NVS plots in the database could not be included in the analysis because they contained large numbers of trees that could not be accurately matched. Overall, a time measurement interval of about 10 years appears to be optimum. This should allow accurate measurement of DBH increment, precise estimates of mortality date, and relatively easy relocation of trees and plots.

Table 28.
Properties of DBH periodic mean annual increment PAI distributions for stems measured over intervals of increasing length.

Measurement interval	**No. trees**	**Mean DBH PAI (cm/yr)**	**Std.dev (cm/yr)**	**Interquartile range (cm/yr)**	**5th-95th percentile range (cm/yr)**
<10 years	2,215	0.092	0.211	0.121 (0.013-0.133)	0.475 (-0.075-0.400)
10-<20 years	5,313	0.099	0.119	0.112 (0.025-0.138)	0.342 (-0.008-0.333)
≥20 years	8,728	0.083	0.111	0.088 (0.019-0.108)	0.304 (0.000-0.305)

The net annual change in volume (taking into account growth and mortality since 1990) is shown for the 20 most important tree species in Table 29. All beech species apart from mountain beech gained in volume since 1990, although the change was statistically significant only for *Nothofagus menziesii*. A commonly occurring North Island canopy tree species, *Knightia excelsa*, increased although not statistically significantly as did the podocarp *Dacrycarpus dacrydioides*. Losses in stem volume were evident in the possum-preferred species, *Weinmannia racemosa*, *Metrosideros umbellata*, *Kunzea ericoides*, *Melicytus ramiflorus*, and *Podocarpus hallii*, but also in the non-preferred species mountain beech, *Quintinia acutifolia*, and *Hedycarya arborea*. Tree ferns are not shown in Table 29 as they did not feature in the top 22 list in terms of above ground biomass carbon (data not shown) – furthermore, tree ferns were not recorded consistently in NVS plots and so the volume change estimates are probably an artifact. Remeasurement of the extensive LUCAS plot network would be expected to clarify growth trends currently evident but not significant based on the NVS subset.

Table 29.

Annual change in live stem volume (growth plus ingrowth minus mortality), and DBH mean periodic annual increment of matched live trees, for the 22 most important species in terms of above ground carbon. P-values indicate whether the volume increment differs significantly from zero.

Species	**% Annual Volume Change**	**s.e.**	**p-value**	**DBH PAI (cm/yr)**
Nothofagus menziesii	0.30	0.14	**0.039**	0.0111
Nothofagus fusca	0.28	0.26	0.289	0.0186
Weinmannia racemosa	-0.27	0.32	0.398	0.0091
Nothofagus solandri Var. *Cliffortioides*	-0.37	0.24	0.142	0.0131
Metrosideros umbellata	-0.48	0.42	0.275	0.0115
Beilschmiedia tawa	0.04	0.36	0.902	0.0097
Dacrydium cupressinum	0.24	0.19	0.225	0.0140
Nothofagus truncata	0.53	0.52	0.333	0.0257
Nothofagus solandri	1.18	0.55	0.060	0.0131
Kunzea ericoides	-1.43	0.43	**0.029**	0.0114
Prumnopitys ferruginea	-0.32	0.47	0.494	0.0108
Griselinia littoralis	0.21	0.17	0.199	0.0114
Melicytus ramiflorus	-0.15	0.34	0.674	0.0044
Podocarpus hallii	-0.33	0.31	0.289	0.0058
Metrosideros robusta	0.35	0.26	0.319	0.0038
Knightia excelsa	1.27	0.63	0.070	0.0132
Quintinia acutifolia	-1.86	3.09	0.569	0.0124
Ixerba brexioides	0.21	0.56	0.725	0.0096
Elaeocarpus dentatus	0.72	0.47	0.175	0.0085
Leptospermum scoparium	1.23	0.88	0.256	0.0098
Prumnopitys taxifolia	0.78	0.32	0.091	0.0345
Dacrycarpus dacrydioides	0.42	0.01	**0.019**	0.0134

3.3 RECOMMENDED RE-MEASUREMENT STRATEGY

3.3.1 Continuous Forest Inventory

This report was also intended to recommend a plot re-measurement strategy. However, since this report was commissioned, a decision was made to re-measure the LUCAS plots over the next five years as originally proposed. The logic behind the proposal and the decision is repeated here.

The basic principle is to remeasure each of the plots once on a nominal five year re-measurement cycle, then extend the re-measurement interval to 10 years in a progressive programme, with the plots subsequently maintained more or less indefinitely. Ten years is generally accepted as a good interval for the indigenous forests and is comparable to measurement intervals in slow growing boreal or temperate hardwood forests. Change is slow, except for catastrophic change, but longer intervals cause problems with timeliness of analysis and results, modification to objectives, dislocation caused by changes in techniques, as well as loss of institutional memory.

The second measurement should ideally be on the anniversary of each plot's establishment / first measurement. The reasons for the first re-measurement being 5 years after establishment rather than 10 are three-fold. Firstly, as soon as possible, to correct the inevitable errors incurred when plots are established in what are difficult conditions. Secondly, to provide statistically and mensurationally sound national estimates of change prior to the end of CP1, or at least its reporting deadline. Thirdly, a relatively short time interval will have elapsed and plot relocation should be easy, with access instructions confirmed. The first re-measurement cycle therefore acts as a quality assurance/control, an error correction process and a measurement of change.

QA/QC should also be carried out in a formal programme of auditing a proportion of the plot by an independent team, but carried out shortly after the main plot visit and in cooperation with both the measurement and audit teams. With about 250 plots being re-measured each year, perhaps a 5% sample should be sufficient, some dozen or so plots each year, perhaps reducing this proportion even further over the years.

It is recommended that the changeover to a 10 year cycle be carried out in a progressive programme over the third measurement, rather than leaving a gap of five years with no programme. For the first tranche of plots to receive a 3rd measurement, half the plots should be visited five years and half six years following the 2nd measurement, the second tranche receive their 3rd measurement half in seven and half in eight years, and so on until the plots are continuously remeasured every 10 years. 120 to 130 plots would be remeasured each year, with differences in detail with regards to some individual plots.

This is termed a Continuous Forest Inventory (CFI) system. Longer term, a CFI has many advantages:

1. Re-measurement becomes routine, with regards to on-going budget, the management, employment and training of experienced field crews.
2. Management costs are significantly reduced as a proportion of the total field measurement programme.

3. Problems (inevitable) occurring in any given year can be corrected in the next, and because of the nature of the analysis of CFI, do not necessarily compromise results and reporting.
4. Analysis incorporating rolling averages or other methods of combining measurements in different years can estimate stocks and change in any, non-predetermined year or interval.
5. CFI is robust to disruption, altering the year of a re-measurement of a plot is not desirable but can readily be accommodated.
6. Changes to techniques, to measurement intensity or to the variables measured can be introduced in an ordered process, usually at a lower overhead and research cost than with periodic inventories.

Measurement for carbon stocks and change is little different than for any other variable of interest. Analysis is easier if there is some consistency in the measurement intervals, but general techniques exist that permit estimation at any given year from plots measured over a multi-year cycle CFI. The techniques need to be made specific to New Zealand conditions, but no real difficulties are envisaged, particularly given the slow change in indigenous forests under normal conditions. Each year there will be some measurements. Change will be measured from paired measurements, reducing variability and increasing precision.

Above all, unexpected, unpredicted change will be noted.

Ideally, each year's set of plots should constitute a random sample of the forest estate and could be analysed on its own, albeit with poorer precision. The distribution of plot locations requires checking – at first glance some years do not appear to have representation in some districts. This is not a critical requirement, but may restrict the range of inferences drawn from any analysis related to year of measurement.

The distribution of sample sites should take into account land-use change. A method is required that incorporates change where land is no longer classified as indigenous forest and shrub, and selects sample plots to be established in new areas. At its simplest, change in carbon ΔC

$$\Delta C = C * A + C_2 A_2 - C_1 A_1$$

Where

C is average stock change per hectare in land present at both times, with area A

C_1 is average stock per hectare in land that was forest/shrubland at time $_1$ but not at time $_2$ with Area $_1$

C_2 is average stock per hectare in new forest/shrubland at time $_2$ with area A_2

3.3.2 Intensity of Sampling

The report provides estimates of carbon stocks in New Zealand's natural forests and shrubland using the vegetation data collected from 2002-2007 by the inventory and also provides estimates of carbon stock changes in the natural forest by a model-based approach using a subset of the NVS plots that were incorporated within LUCAS.

At the current sampling intensity, the total carbon contained in live above ground biomass in New Zealand's indigenous forests can be predicted at ± 3.8 % of the total, i.e. the true total amount is likely to be between 859 and 927 M tonnes, with a 95% probability. Total live and dead carbon, excluding soil can be predicted to within ±3.5%, excluding the errors in the equations that convert the field measurements to carbon estimates and errors in the field measurements themselves contained in the database. This level of precision, or uncertainty, is quite good at the national scale. It would be feasible to reduce the sampling intensity while still retaining a reasonable level of confidence in the estimates if only national figures were of interest. However, for the results to be able to be used in a tactical or operational sense, estimates must be provided for regional or other subdivisions, for example, by island, by species, or by the group of species susceptible to Possum browsing. Uncertainty rapidly rises as the number of samples decrease, almost doubling to ± 7.1% for the estimate of live above ground forest for the North Island for example. The confidence interval for New Zealand's iconic species, Kauri, is ± 20.1%. As users become familiar with the information that can be derived from the inventory, more analyses will be carried out for subdivisions of interest.

In Shrubland the equivalent figures are an uncertainty of ± 15.5% in total carbon in live above ground biomass, with the true total amount likely to be between 82 and 103 M tonnes. Thus for Shrubland, while the uncertainty is much higher in percentage terms than indigenous forest, in absolute terms it is ± 13.8 M tonnes, less than that of the forest. However, when subdividing the total area into meaningful components, for subalpine shrubland for example, the confidence interval is an unreasonably high ±56%. Shrubland is composed of a wide variety of plant communities and the designated area from both LCDB and Ecosat includes many plots that the ground teams classified as high forest. It is also the land class that is subject to more dynamic change, with afforestation, natural regeneration and "scrub" clearing. A more detailed, objective-driven, spatial analysis is required of the data than possible in this report. Note the problems in the measurement and assessment of change discussed earlier in the report that highlight that methods of calculating uncertainty in shrubland for meaningful populations are themselves uncertain. It therefore recommended that no economies in sampling effort for shrubland stocks be attempted at this early stage of LUCAS.

Based on the analysis of the historical NVS data described earlier, live above ground carbon stock has increased slightly but not significantly between 1990 and 2004 (the mean measurement year of the LUCAS data). If changes in both live and dead pools are considered, New Zealand's natural forests were shown to be a carbon sink.

In order to estimate change since 1990, the NVS plots that had been incorporated into LUCAS were used in a model-based statistical analysis approach. Of the 1257 sample sites, teams were able to re-locate and re-measure an existing NVS plot in 191 sites. Virtually all were in forest, the few in shrubland constituted too small a sample to be of use. Following error analysis, 151 plots were used in regression model development and 142 to predict carbon stocks at 1990 utilising the 889 plots that fell in the EcoSat mapped forest area and hence predict carbon stock change. The change in carbon live above ground biomass stocks over the 14 years 1990 to 2004 is estimated at 2.74 ± 4.5 t/ha. This change can not be shown to be significantly different from zero, i.e there is no proof that total live forest biomass is increasing or decreasing. Including dead coarse woody debris results in an estimated increase of 8.5 ±2.6 t/ha carbon in the total above ground biomass, that is between 6 to 11 tonnes carbon per hectare over the 14 year period, or somewhere between 37.5 and 70.3 M tonnes carbon for the indigenous forest as a whole. The confidence limits are therefore of the order of ± 30% of the change estimate. However, the estimated change is itself a small percentage of the estimated total above ground in 2004, and expressing confidence intervals as percentages in this situation can be misleading, even more so when the estimate tends towards zero. The critical question is whether the uncertainty expressed in absolute values is too large or not.

The confidence intervals and uncertainties of the change estimates discussed above only concern plot to plot sampling variation. An implicit assumption in the method used to calculate change is that the change function developed from the NVS plots applies to all the plots across the whole forest and that there does not exist a subset where some different relationship exists. This does not appear likely. This assumption will not be material when the plots are re-measured and change from 2002/03 onwards estimated. It would be desirable to calculate change immediately following the re-measurement of the plots in 2009 rather than waiting for the full five years.

Given the above factors in the production of stocks and stock change estimates, given the overall cost of LUCAS, including management and associated research, then it is suggested that at this stage attempting to economise on field measurements would be unwise.

It is thus recommended that:

1. The second field measurement between 2009 and 2013 of all existing plots, plus new plots in new forests and shrubland or where access is now granted, proceed as planned and budgeted.
2. At the very least in the first year or two, a proportion (perhaps 5%) of the plots be re-measured independent of the main field measurement in a QA/QC process.
3. As plot data is produced, error checking, verification and carbon analysis proceed without waiting for the complete inventory
4. Long range planning budget for a third measurement between 2014 and 2023, with the sampling intensity at the national intensity remaining at the current levels, i.e. 1 plot every 8 sq km, but at half the annual rate of plot measurement.

CONCLUSIONS

The installation and measurement of 1256 permanent plots located within the natural forest and shrubland land category of the LCDB1 has provided statistically robust estimates of carbon stocks nationally with a relatively high level of precision.

While some data issues were unresolved, we believe that any remaining measurement errors will have a relatively small impact on the carbon stock estimates. Issues such as species identity, and stem diameter and height measurement errors will no doubt become apparent following the next remeasurement of the LUCAS plot network. The dimensions of all plots should be checked in the field as part of the remeasurement. In particular, trees in the 20 m radius circular plot appear to have been missed, possibly biasing carbon stock estimates by -8%. Restricting the analysis to the 20 x 20 m square plots increases the standard error of the stock estimate dramatically by 38%.

Table 30.
Total carbon stocks (Mt) based on measurements in the 20 x 20 m square plots and the 20 m radius circular plots combined, compared with using the 20 x 20 m square plots alone.

Source	20 m circular + 20 x 20 m square plots		20 x 20 m square plot	
	total	**s.e.**	**total**	**s.e.**
Total (Mt)	1538.9	28.1	1665.0	36.7

Ideally NVS plots would have been selected as a representative sample from the full set of LUCAS plots to ensure that stock estimated in 1990 and stock change estimates are unbiased. In practice, the selection of NVS plots over-represented beech types in the South Island. Our analysis using regression analysis is an attempt to overcome this potential source of bias due to the way NVS plots were selected. Remeasurement of the entire plot network will allow further refinement of the 1990 baseline estimate.

Coarse woody debris was not measured in NVS plots. The CWD pool in 1990 was therefore estimated from the CWD stock estimates in LUCAS plots in 2002-2007, the tree mortality data, and expected decay rates. Decay rates are known to vary by tree species by a factor of at least two (Beets et al., 2008a), however the species identity of a large proportion of the CWD was unknown when assessed in LUCAS plots. Decay rates also vary by fungal species by a factor of two (Beets et al., 2008a), however the incidence of decay fungi is not currently assessed. For current purposes it was assumed that the average decay rate across all species could be applied. In future, the rate could be applied by species, taking into account temperature effects on decay rates following methods given in Beets et al. (2008a)

Carbon stock changes since 1990 could not be estimated for shrubland, because most NVS plots with historical data were in forest. The methodology for estimating carbon stock changes in shrubland is quite different from that used for forest, and has currently not been tested. Testing of the shrubland methodology warrants urgent attention because 1) carbon stocks changes are expected to be appreciably greater in seral shrubland (ie. successional stages to forest) than for mature forest, and 2) the

LUCAS methodology should ideally underpin that used for estimating carbon sequestration rates in relation to the Emissions Trading Scheme (ETS).

Data collected by the LUCAS project will be able to achieve wider sector benefits in relation to for example the Emissions Trading Scheme (ETS) if shrubland plots are aged, while ensuring that stock change estimates are valid.

Data collected by the LUCAS project will be able to provide improved estimates of CWD decay rates if the incidence of decay fungus, Ganoderma is assessed, which will provide an improved basis for modelling CWD stock changes from tree mortality data in future.

The second field measurement between 2009 and 2013 of all existing plots, plus new plots in new forests and shrubland or where access is now granted, should proceed as planned and budgeted. At the very least in the first year or two, a proportion (perhaps 5%) of the plots be re-measured independent of the main field measurement in a QA/QC process. As plot data is produced, error checking, verification and carbon analysis should proceed without waiting for the complete inventory.

Long range planning should budget for a third measurement between 2014 and 2023, with the sampling intensity at the national intensity remaining at the current levels, i.e. 1 plot every 8 sq km, but at half the annual rate of plot measurement.

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Appendix 1. Description of corrections to database tables

Table t527_StemDiamHt error checking procedures for the LUCAS and NVS plot tree dimensions

Measurements of stem DBH and a sample of heights of all live stems and DBH and spar height of all standing dead stems in CMS IF (indigenous forest and shrubland) plots, including earlier NVS historical measurements, are contained in Table t527 in the LUCAS database. There are 198,923 records in the table, each representing a measurement of a single stem.

The minimum information required for each measurement record consists of the id for stem DBH and height (id is a unique reference number for each record in the table, which, as in other tables also, was required for making corrections to the data), the survey id (date of the re-measurement, which was required to estimate stock changes since 1990), the CMS plot code and, except in some historical NVS records, the subplot giving the location of the stem for estimating height and forest class), a 6-letter species code for estimating the height of trees without height data and assigning a whole stem wood density to each stems), stem tag (which was required to track trees with more than one measurement), the stem status code (A for live and X for dead stems and decay class (which were used to modify whole stem wood and bark density of dead stems based on the decay class), the DBH (cm) of each stem and the height (m) of a sample of stems (used to estimate stem volume). Stem height (m) was recorded for 44,483 of the records. Other information present included the stem lean angle and direction for stems where lean angle exceeding 20 degrees, however, because key information was missing, it was not possible to define a calculation procedure to reliably correct height for lean angle, and therefore all stem height measurements with a lean angle recorded were excluded from further analysis.

A subset of the CMS plots consists of historical NVS plots and these have at least 2 measurements. There are currently 191 NVS plots in the database. Considerable time was spent reconciling the earlier measurements with the most recent CMS measurement in these plots. The NVS measurement closest to 1990 and the CMS measurement were used in the calculation of carbon stock changes over time. Only these two measurements were thoroughly checked. Procedures similar to those described below could also be applied to other earlier NVS measurements for completeness, but were not necessary for the calculations contained in this report.

Checking was performed in several stages. Some errors were corrected using automatic routines (e.g., checking species codes against an established species list, and matching tags using final letters of tag codes). In addition, likely measurement and database errors were identified using range checks and charts, and these were checked against PDFs of the original plot sheets. Errors that were due to data entry errors were simply corrected. Errors due to measurement errors were dealt with on a case by case basis, as described in the summary of checks section that follows.

Summary of the checks:

- Species code check. A number of species codes used in earlier NVS measurements had been changed. It was generally possible to recode these automatically using the latest name code. In addition, many species codes had been miss-punched or incorrectly coded in the field. When the correct code was obvious, these were corrected. Species code corrections were applied to a total of 2489 records.
- DBH too large. For each species, the mean and standard deviation of the log transformed DBH was calculated. Stems with ln(DBH) more than 4 standard deviations greater than the species mean were checked. Of the 154 stems identified using this criterion, 74 were found to have erroneous DBH entries and were corrected. In addition, the 55 stems greater than 175 cm DBH were all checked and 7 erroneous entries were corrected.
- DBH missing. DBH was missing for 56 records and 26 were corrected.
- Height too large. For each species, the mean and standard deviation of height was calculated. Non-leaning stems with height more than 4 standard deviations greater than the mean were checked. Of 101 stems identified using this criterion, 40 were found to be erroneous and corrected.
- Height too small. Heights were less than 1.4 m in 149 records and 137 of these were found to be erroneous and corrected.
- Height too small relative to DBH. When both height and DBH was measured, it was possible to identify outliers by assessing height relative to DBH. It was determined graphically that, except for tree ferns and leaning trees, when ln(height-1.4) was less than $1.5\text{-}3.6\times DBH^{(-0.3)}$, the height was likely to be too small relative to the DBH. Of 47 stems identified using this criterion, 39 were found to be erroneous and corrected.
- Height too large relative to DBH. It was determined graphically that when height was greater than $12+0.7\times DBH$, the height was likely to be too large relative to the DBH. Of 43 stems identified using this criterion, 31 were found to be erroneous and corrected.
- Incorrect units. Many historical NVS DBH measurements were entered into the database in millimetres rather than centimetres - 1068 records were corrected.
- LCR checks. LCR supplied NVS tag code punching errors for 743 records.
- Automated NVS tag change. Many historic NVS records contained incompletely entered (truncated) tag codes. It was possible to correct many of these automatically by matching the last 3 or 4 letters of the codes. Some 7,887 records were corrected in this manner.
- Manual NVS tag change. A chart and table of DBH growth for each stem was produced for each NVS plot. This also showed ingrowth (trees appearing for the first time in the CMS measurement) and dead trees. Typically, a few ingrowths in each plot were clearly too large to be genuine. These errors were generally caused by incorrect matching of NVS and CMS tag codes. In this case, the large 'ingrowths' would always be matched by 'mortality' trees that had apparently died, but were in reality the same tree. It was often possible to match the tags correctly by referring to the plot sheet PDF. Matching was also inferred when a CMS 'ingrowth' matched a NVS 'mortality' stem in terms of species, subplot and DBH, and when no evidence of the NVS tree was apparent in the CWD data. Correcting these errors was often laborious, but in most cases, satisfactory reconciliation between NVS and CMS measurements was possible. Some 2,930

records were corrected in this manner. NVS PDF's with tree data were missing (ie. not in LCR plot sheet archive) for plots CP92, CX69, and CN94 – apparent ingrowth and mortality issues for plots CP92 and CX69 seem to have been resolved, while CN94 had too many issues to resolve without having access to NVS PDF.

- Manual NVS tag changes that still need to be made. Ingrowth and dead trees were accepted as legitimate but may infact not be in the case of small stems. Trees that were too small to be identified as not genuine ingrowth were included in the stock and change calculations, and will result in a slight overestimation of ingrowth and mortality, and a slight underestimation of growth of persistent trees. If this type of error is addressed, then it will also be possible in future to estimate the FWD stock of trees between 2.5 and 10 cm DBH that died since the last measurement.
- Tree ferns often erroneously appeared as ingrowth using the checking procedures developed for trees, and these checks for ferns were therefore ignored. While gross errors in height v DBH relationships were corrected, tree ferns did not receive the same level of checking as occurred for tree and shrub species. Considerably more tree ferns were measured in NVS plots (847 live stems) during their 2002-2007 remeasurement as LUCAS plot than occurred when measured previously as NVS plots (226 live stems), which indicates that ferns were often not measured prior to 2002. A total of 161 of the 226 live tree ferns were matched.
- Implausible DBH growth trend that could be corrected. The charts and tables used in previous steps identified stems that appeared to have grown too fast or slow in DBH relative to that for other stems in the plot. DBH corrections to 57 records were made after, referring to plot PDF sheets.
- Even after applying the above checks, some 'ingrowths' in CMS were simply too large to be plausible, and could not be matched with 'mortality' trees in the NVS measurement. In many cases, these were boundary trees that were not within the original NVS plot, or must simply have been missed in the earlier measurement. Also, some implausible DBH growths (or decrements) could not be reconciled. In these cases, the stems were included in the carbon pool calculations but excluded in the carbon change calculations. A total of 386 records belonged to this category.
- In addition, measurements in 41 records where the DBH or height were considered totally implausible and could not be corrected were ignored in all calculations.
- Incorrect tree status codes. In the process of examining NVS plots and apparent outlier trees, 67 stems entered as 'live' in the database were found to be actually 'dead'.
- A further 35 records were eliminated for other reasons (e.g., duplicate entries, stems less than 60 cm DBH in EXT subplots). In several cases, the subplot number allocated to a stem had been changed to EXT by field teams because the NVS tree was deemed to be outside the plot – in such cases, the original subplot number was re-assigned and the stem measurements accepted as legitimate for calculation purposes.
- Missing records. Occasionally, stem measurements were simply not entered in the table. Some 44 of these were identified and inserted.
- Missing decay class for standing dead CWD. Some 72 dead stems had missing decay classes. These were checked and 35 which found to have decay classes

recorded on field sheets were corrected. The remaining 37 stems were left blank in the table. However for calculation purposes all missing values were assigned a decay class of 2 as the default value, because this was the most common class for standing dead trees in the database.

- Double count of carbon. Plot W167 stem data should be ignored – the carbon stock for this plot was based on the discrete shrub calculation method. It appears that only one plot included shrubs that were measured not only as discrete shrubs but also as trees (ie tagged trees with stem data, and also discrete shrub data for the same individuals).

One issue that arose during checking was to decide whether entries that appeared to be erroneous should always be corrected in the database. As a general rule, it was decided to retain entries as recorded on field sheets, except where these were clearly erroneous and the correct values could be readily determined. For example, miss-spelt species codes were corrected as were outdated species codes used in earlier NVS measurements. However, when comparing NVS and CMS measurements it was found that 763 stems had different species codes at each survey date. In this case the recorded species codes were retained in the database as long they represented valid species. During processing, the latest (CMS) species code was used, e.g., to determine the wood density. Another example concerns dead standing stems which should all have been given a decay class. Occasionally the field crew omitted to do this and it appears that these missing values were often assigned a code of 2 when entered into the database. We believe a better strategy for this situation would be to leave the record blank in the database, and use an appropriate rule (e.g., missing decay class assumed to be 2) when processing the data. However, to remove these assumed values from the database would require checking all standing dead entries against field sheets and was beyond the scope of this project.

In all 12,170 record changes were made to Table t527, although the majority of these consisted of NVS tag matches. In addition, 42 missing records were added to the table.

As a result of these corrections, stem measurements in all 1257 CMS plots are now all within reasonable limits, although some data entry and measurement errors undoubtedly still exist. These errors are expected to have only a minor influence on carbon pool calculations, and it is therefore recommended that remaining errors be re-addressed later, after the plots are re-measured, when more refined testing of DBH growth trends can be used to identify and eliminate these errors.

Of the 191 NVS plots in the database, virtually all contained some errors and were therefore initially not usable. Note that even the incorrect identification of a single large stem can completely invalidate the carbon change calculation for an individual plot. After applying the corrections outlined above, 166 of these plots are now considered clean enough to provide reliable carbon change estimates. Although plots may still contain errors, these will all be confined to smaller stems which have minimal impact on carbon change estimates. For example, both ingrowth and mortality will be overestimated and growth of persistent trees underestimated where tree tags are miss-matched, but this will be confined mostly to small trees, and therefore the impact on stock change calculations can be expected to be minimal. Of the 25 NVS plots currently rejected, several are potentially salvageable, and it is recommended that this be undertaken at a future date, although they would require many further hours work to achieve this result. Most of the remaining 25 plots can not be used as they contain large numbers of stems that were not relocated and matched in the field.

Table t525_CWDPieces error checking procedures for forest and shrubland plots

Measurements of coarse woody debris CWD in forest and shrubland plots are contained in Table t525 in the LUCAS database. There are 25,062 records in the table, each representing the measurements for a single piece of CWD.

The minimum information required for each measurement record consists of the id for CWD, a 6-letter species code for assigning a whole stem wood density to each section, the CMSID, Subplot and Tag (which were only used to resolve issues associated with stem mortality in relation to t527), the decay class (which was used to modify whole stem wood and bark density of dead stems based on the decay class), the LED and SED (cm) of each CWD section and the CWD length (m) (which were used to estimate CWD volume).

Checking was performed in several stages. Some errors were located using automatic routines (e.g., checking species codes against an established species list). Likely database errors were identified using range checks, and these were checked against PDFs of the original plot sheets.

Summary of checks:

- Species code check. Species codes had been miss-punched or were incorrectly coded in the field. When the correct code was obvious, these were corrected. Species code corrections were applied to a total of 44 records.
- CWD category check. Stumps were frequently inconsistently coded as "P", instead of "S" - Some "P" codes were actually fallen logs (not stumps) with missed SED measurements. Suggest global replace of “P” with “S”, unless there is a good reason for also having a “P” code in which case it will need to be defined consistently.
- CWD diameter out of range check. CWD was defined as material ≥ 10 cm in diameter in the 20 x 20 m plot and ≥ 60 cm in diameter in the 20 m radius plot. Excessive diameters were generally located using ratio methods, as described below, though some issues related to measurement units were identified using simple range checks. Some CWD was splintered, in which case diameters can legitimately be less than 10 cm.
- Length check - look at CWD ("F" code - ie excluding stumps) where LED is >30cm and CWD length is <0.3m. Note that there are frequently CWD of 0.1m in length, which is odd unless log measured in taper steps, but often no brackets to suggest this.
- CWD diameter checks. The ratios LED1/LED2, SED1/SED2, LED1/SED1, LED2/SED2 were calculated and checks (against PDF) undertaken where these were less than 0.3 or greater than 4. These ranges were set by trial an error, when checking PDF files suggested values were acceptable. Errors were mostly data entry errors.

- Inappropriate decay class codes. Some decay class 4 CWD was measured, however the manual reserves decay class 4 for CWD where loss in shape precludes volume measurement. Inspection of class 4 coded CWD indicated that the logs had not lost their shape ie. LED1 was similar to LED2, etc. While the data were not altered, these CWD sections were treated as decay class 3 for calculation purposes.
- Some CWD pieces were missed during data entry – finding a few missing records requires a line by-by-line verification of the data, which was beyond the scope of the current project, although records were inserted when such errors were noticed.
- It is likely that some CWD pieces were missed by field teams, but the magnitude of this possible error will only become evident after the plots are remeasured.

In all 114 record changes were made to Table t525, although the majority of these consisted of NVS tag matches.

As a result of these corrections, CWD measurements are all within reasonable limits. There are potential errors remaining in CWD lengths - particularly when CWD is apparently very short (0.1 m) but the diameter of log is large. It is recommended that this apparent issue be checked during the re-measurement of plots. CWD record ID 25774 is an example of this type of error, where the field sheet recorded 10 (10 m), the LUCAS database entry was 0.1m (very short section), but the length measurement was probably 1.0m given the section taper. Although errors undoubtedly still exist, these are likely to have only a minor influence on carbon pool calculations.

Table t538_ShrubDiscrete error checking procedures for subplots measured using the discrete shrub methodology

Measurements of discrete shrub dimensions in shrubland plots are contained in Table t538 in the LUCAS database. There are 20, 081 discrete shrub records in the table, each representing the measurements of a discrete shrub or shrub clump.

The minimum information required for each measurement record consists of the id for discrete shrub, the CMS plot code and the subplot (giving the location of the shrub for estimating carbon), a 6-letter species code for estimating the carbon in each shrub, and orthogonal width1, width2 and Ht of each shrub or clump for estimating carbon.

Checking was performed in several stages. Some errors were corrected using automatic routines (e.g., checking species codes against an established species list). In addition, likely database errors were identified using range checks and charts, and these were checked against PDFs of the original plot sheets.

Summary of checks:

- Species code check. Species code errors were not evident for discrete shrubs.
- Width out of range check. Data where width1 or width2 were zero or >4 m were all checked against PDF files. All shrub dimension data (widths and height) for plot AU126 were re-entered because the data were inappropriately rounded to nearest 1m during data entry. The ratio of Width1/Width2 was calculated and PDF files checked if the ratio appeared excessively high or low. A particular

value was not set. Apparently excessive ratios were each checked until data entry errors were no longer evident, based on the PDF files.

- Height out of range check. Heights <0.3 m and greater than 4 m were all checked for data entry issues or measurement errors.
- Shrubs missed during data entry – finding a few missing records requires a line by-by-line verification of the data, which was beyond the scope of the current project, although records were inserted when such errors were noticed. Three records were inserted.
- Avoidable double counting of carbon stocks. Shrub in one plot (W167) had been measured twice – once as a tree and again as a discrete shrub, even though many stems were ≥ 2.5 cm in DBH. To avoid double counting of carbon for this plot, the carbon stock estimate based on the discrete shrub methodology was used, because this was considered superior to that obtained using the tree methodology, which does not include stems < 2.5 cm DBH.
- Unavoidable biases evident. Some plots contained subplots where the tree and shrub methodology were both used in the same subplot, albeit on different individuals (discrete shrub method for stems < 2.5 cm DBH and tree method for stems ≥ 2.5 cm DBH). In shrubland plots measured using discrete shrub methods, double counting will not occur, however, a switch between methods (shrub versus tree method) over time can be expected to lead to stock estimation bias, and consequently to bias in the stock change estimates, which is of concern.
- Avoiding potential bias in stock change estimates. It is recommended that the issue of bias referred to above be addressed prior to the re-measurement of shrubland plots, particularly for plots that are regenerating back into forest. A switch between these two assessment methods is currently allowed within a plot at a given time, and by default can be expected to occur over time following growth of shrubs over to current 2.5 cm DBH threshold.

Excluding corrections associated with plot AU126, nearly 100 record changes were made to Table t538, the majority of which were data entry errors. These errors were in some case to be expected because of measurement unit changes that were made to field forms over time.

As a result of these corrections, discrete shrub measurements are all within reasonable limits. Although some errors undoubtedly still exist, these are likely to have only a minor influence on carbon stock calculations. Of greater concern with respect of carbon stock and change calculations are temporal switches between the current available measurement methods - and consequently the calculation methods - when shrub plots are re-measured in future.

Table t541_ShrubsContinuous error checking procedures for subplots measured using the continuous cover methodology

Measurements of shrub height (quadrant heights) in shrubland plots are contained in Table t541 in the LUCAS database. The height records in this table each represent a measurement of shrub height at an identified quadrant. Quadrant data were collected at 5 x 5 m grid intersects of subplot within each of the main 20 x 20 m plots and also at 1 x 1 m grid intersects of biomass harvest subplots adjacent to the main plot.

The minimum information required for each measurement record consists of the id for continuous shrub, the CMS plot code giving the location of the plot (for estimating the shrub carbon stock), the plot type (20 x 20 m for main plot, or 2 x 1 or 4 x 1 for biomass harvest subplots) which define the number of valid quadrants in a subplot, the quadrant number (points where a 0.20 x 0.20 m quadrant was placed over a grid intersect), and the height of shrubs at each quadrant. Cover percent was also recorded at each quadrant – but this was not used in carbon calculations because 1) it is a subjectively assessed score of dubious repeatability for stock change detection, and 2) analysis showed that this variable did not explain any of the variation in shrub biomass carbon in harvest table (t539).

Checking was performed in several stages. Likely database errors were identified using range checks, and these were checked against PDFs of the original plot sheets.

Summary of checks:

- Quadrant height out of range check. One height was incorrectly entered. Others heights that appeared to be out of range were in forest plots with FREBAN (Kiekie), which climbs to a considerable height up individual trees in forest plots. These quadrant heights were left in the database. Plots with kiekie were excluded from the analysis, through adjustments made in the calculation procedure. Their exclusion was warranted because 1) field methods were not documented in the manual for FREBAN growing in forest plots, 2) the field methods for continuous shrubland had been used for FREBAN but the field procedure was either flawed or not adhered in relation to kiekie (for example, Plot AA139 had no shrub area information collected, and so quadrant information could not be used). Quadrant heights failed to meet the 0.3 m threshold in some plots - the database was not altered however these values were replaced by zero in the calculation procedure.
- Other quadrant height checks. These revealed a significant number of quadrants where a legitimate value of zero was expected to occur but records were entirely missing from the database. A business rule had been applied (Hamish Marshall, pers comm.) that deliberately removed all quadrant records with zero height recorded from the database. Consequently, calculations of continuous shrub mean height by subplot, based on the quadrant data, will be erroneous. This error was corrected by inserting zeros where necessary within the calculation approach, with no alterations made to the table. Records for quadrants with zero shrub height values will need to be inserted into the database, possibly through running an automated global insert algorithm.
- It should be noted that quadrants with a non-zero value but no continuous shrub vegetation present at the grid point (because a discrete shrub occurred there) were retained in the database, and these heights were used in calculations of continuous cover mean height. Inclusion of all quadrant heights for a subplot was considered necessary to avoid bias in future carbon stock change calculations for mixed discrete/continuous cover shrub plots that grow to become entirely continuous cover plots – for no other reason than quadrants with existing continuous shrub cover may likewise have been occupied with discrete shrubs at an earlier time.
- Invalid total number of quadrants. The total number of quadrants is 25 in a 20 x 20 m plot, 10 in a 4 x 1 m biomass subplot, and 12 when two 2 x 1 m biomass subplots are installed. Based on this check, the plot type information was found

to be incorrect for one 20 x 20 m plot. This error was corrected in the Scion copy of the data table. A complete check was then made of the continuous biomass harvest subplot information, and many errors were found there, although it should be noted that plot type corrections for biomass subplots are not documented in the correction sheet for table t541.

- Missing quadrant height information. Some plots were entirely missed, and the required data were inserted directly into the table for calculation purposes, as found for BI123, BY112 for 20 x 20 m area plots, and for CN96 and BI 123 4 x 1 m and BY112 2 x 1 m biomass subplots. For these plots biomass harvest data had been entered in table t539 or continuous cover information had been entered in table t543.
- Invalid shrub plot data that resulted in unavoidable double counting of carbon stocks. Plots with continuous cover measurements for subplots where tree measurements had also been made were evident in the database. Obvious double counting occurs when a subplot is occupied by continuous shrub cover over 100% of its area and tree measurements are also recorded for the same subplot. Where shrub cover occupies less than 100% of the subplot area, double counting can be avoided, provided that an appropriate reduction is made of the shrub area of a subplot occupied by crowns measured as trees. It is noted that mixing continuous cover and tree methods within a subplot requires highly subjective assessments and is potentially fraught with errors. These errors can be expected to lead to bias in carbon stock change calculations following future assessments of these plots, because the assessments of crown occupancy in dynamic plots is subjective, and because the calculation methods are also different, which in itself can be expected to lead to biased - as noted also in relation to shrubland plots with discrete shrub measurements in combination with tree measurements in the same subplot.

As a result of these corrections, continuous shrub measurements are all within reasonable limits. Although some errors undoubtedly still exist, these are likely to have only a minor influence on carbon pool calculations, apart from double counting of carbon stocks that occurs when fully occupied continuous cover subplots were also measured as tree subplots.

Table t543_ShrubLayout error checking procedures for subplots measured using the continuous cover methodology

Measurements of shrubland site occupancy (or more specifically the amount of ground area assessed by field teams as being occupied by continuous shrub cover) are contained in Table t543 in the LUCAS database. There are 1118 records in the table, each representing a measurement of an individual shape (triangle, square, rectangle) within a subplot.

The minimum information required for each measurement record consists of the id for shrub layout, the CMS plot code giving the location of the shrubland vegetation for estimating shrub carbon, subplot identity which is required to correctly link the subplot mean height estimate (based on quadrant heights in t541) to the appropriate shrub subplot area information, the length of the shape sides (X1, X2, X3), and the shape itself (square, rectangle, triangle).

Checking was performed in several stages. Likely database errors were identified using range checks, and these were checked against PDFs of the original plot sheets. In addition, mathematically impossible shapes were identified and corrected as indicated.

Summary of checks:

- Out of range checks – area of subplot covered by continuous cover shrubs can not exceed 25 m^2.
- Invalid triangle shape measurements for area calculation. All triangle shapes were assumed to be general triangles, the area of which was calculated using Heron's formula. Six corrections to field measurements were required owing to invalid dimensions. Three corrections were to field measurements entered in the database, and an additional three to field measurements not yet entered into the database). In each case variable X3 was also checked using Pythagoras formula. Invalid data were corrected according to Pythagoras formula.
- Incorrect data entry. The X1 and X2 data for plots BB111 and U143 were re-entered to correct errors. Plot BD107 had invalid character entered under X3.
- Missing data. Data for 11 plots were entered because they were missing from the database, with a total of 176 records inserted into the database.
- Invalid data. Area data were entered but the plot was actually measured as a discrete shrubland plot. Delete plots DS60 and P154 from table t543.

Excluding corrections associated with plot BB111 and U143, approximately 180 record insertions and corrections were made to Table t543, the majority of which were data entry (missed records) errors. Plots DS60 and P154 were left in table t543, but these data were not used.

As a result of these corrections, shrubland continuous cover area estimates are all within reasonable limits. Although some errors undoubtedly still exist, these are likely to have only a minor influence on carbon pool calculations.

Table t539_ShrubBiomassHarvest error checking procedures for biomass data obtained using either the discrete or continuous cover methodology

Measurements of shrub biomass in discrete and continuous shrubland plots are contained in Table t539 in the LUCAS database. There are 399 shrub records in the table, each representing measurements of the fresh and dry weight of either a single discrete shrub/clump or a unit area sample of continuous shrubland comprised of one or more shrubs.

The minimum information required for each measurement record consists of the id for shrub biomass sample, the CMS plot code giving the location of the shrubplot, the methodology employed - either discrete or continuous, a 6-letter species code for discrete shrubs and the main species for a continuous shrub harvest, shrub dimensions of height and width 1 and width 2 and individual shrub number for the 4 most common discrete shrubs harvested, height and percentage cover of subplot measurement points for the continuous shrub harvest quadrat, dimensions and slope of the continuous shrub harvest quadrat, individual total fresh weight of the 4 most common discrete shrubs or components (if subdivided) harvested, subsample fresh weights of discrete shrubs or components harvested if whole shrubs or components too large for dry weight determination, total fresh weight of a bulk sample of continuous shrubs or components harvested, subsample fresh weight of continuous shrubs or components harvested if whole quadrat too large for dry weight determination, dry weights of discrete or continuous shrub samples or subsamples.

Checking was performed in several stages. Some errors were corrected using automatic routines (e.g., checking species codes against an established species list). In addition, likely database errors were identified using range checks and charts, and these were checked against PDFs of the original plot sheets.

Summary of checks:

- Incorrect CMSID. Alphabetical characters had been reversed.
- Two shrubplots with harvest data completely missing from database. Found by comparing listed biomass data with plot ID in database.
- Incorrect subsample fresh weight in database. Comparisons of biomass fresh/dry ratios and shrub cuboid (crown volumes) densities prompted checks with original PDF files.
- Incorrect continuous shrub biomass harvest quadrat size in database. Checked against original PDF files
- Issues with discrete shrub width measurements giving suspect cuboid densities outside acceptable ranges.
- Issues with shrub biomass fresh/dry weight ratios outside acceptable ranges which indicated possible errors in weighing samples fresh or dry. Factors such as harvesting and weighing saturated samples on wet days probably contributed to the data outliers particularly where samples were small. However where whole samples were taken for dry weight determination and no subsampling occurred density and weight per unit area calculations are unlikely to be affected. Where these issues could not be resolved suspect data was omitted from the analysis and carbon calculations.

As a result of these corrections, CMS shrub measurements are all within reasonable limits. Although some errors may still exist, these are likely to have only a minor influence on carbon pool calculations.

Table t540_ShrubContinousBiomasslayout error checking procedures for biomass subplot dimensions

Measurements of biomass harvest subplot horizontal areas are contained in Table t540 in the LUCAS database. There are 53 records in the table, each representing a single subplot adjacent to the main plot where continuous cover shrubs were harvested on a per unit area basis.

The minimum information required for each measurement record consists of the id for continuous shrub biomass plot layout, the CMS plot code for linking to the subplot quadrant data and biomass harvest dry weight data, the tape length and slope measurements (long and short axis) of the harvested subplots.

Checking was performed in several stages. Likely database errors were identified using range checks and charts, and these were checked against PDFs of the original plot sheets.

Summary of checks:

- Inconsistent axis lengths. The most common data entry error involved tape distances. These were typically entered as the nominal distance (4 on long axis, and 1 m on short axis) apparently without reference to the field sheets where the actual measurements were recorded. Each field sheet was therefore checked and corrections (27 in total) made when necessary.
- Missing subplots. In addition, subplot measurements for 10 plots had not been entered in the database. These records were inserted in Scions version of the table.

Cross-checks with vertex horizontal distance measurements were also made, however measured horizontal distances were not used for carbon calculations. The Vertex is not expected to be accurate over such short distances, and therefore the tape distance and slope information was used in all cases. This check confirmed that subplot horizontal dimensions that were calculated from tape distances and slope measurements were reasonable for calculating the biomass subplot horizontal areas.

Table t521_IFLayout error checking procedures for 20 x 20 m plot dimensions
Measurements of the main plot layout in forest and shrubland plots are contained in Table t521 in the LUCAS database. There are 6788 records (this number will increase when the amalgamated records are corrected) in the table, each representing measurements of an edge section of a 20 x 20m plot.

The minimum information required for each measurement record consists of the id for plot layout, the CMS plot code (for calculating the carbon stock per plot on a horizontal area basis), the line number (which Scion inserted in table 521 to identify section measurements (single or multiple) along the four axes of the plot (1 corresponds with axis A- D, 2 with axis D – M, 3 with axis M – P, and 4 with axis P - A), the tape distance and corresponding slope and horizontal (Vertex) distance. NVS plots were assigned the same area that was measured in the CMS plot, because the manual states that no realignment of axis existing plots should be undertaken.

Checking was performed in several stages. Likely database errors were identified using range checks and also charts to locate outliers, and these were checked against PDFs of the original plot sheets.

Summary of checks:

- Horizontal distance deviates excessively from slope corrected tape distance. Where the tape distance, slope angle, and horizontal distance had been measured and recorded by line section, tape distances were slope corrected by line section and compared with the directly measured horizontal distances. Line sections that deviated by more than 1 m were considered to be out of range. These outliers were checked against PDF's, and data entry errors (in tape distance, slope angle, horizontal distance) were corrected. Measurements that deviated by more than 1 m were accepted unless data entry or recording errors were apparent.
- Tape distance measurement in field was not recorded by line section. Where only the cumulative tape distance along the axis was recorded, an attempt had sometimes been made (by Interpine) to partition this into line sections corresponding with the slope measurements. Partitioning of the tape distance this way was not essential but nonetheless useful, as this allowed a rough check of the directly measured horizontal distances. Where incorrect assumptions had been made regarding how the tape distance should be partitioned into line sections, the data were corrected to improve the validity of the above check. In such cases, the horizontal distance should not have been altered – if it had been, the field value was reinstated unless the differences was ≤ 5 cm.
- Tape distance was not recorded but slope was. Inferred tape distances (from horizontal distance and slopes) were found but these were sometimes not acceptable (eg plot S148). In most cases, however, the tape length was assumed (by field team) to have been 20 m on each side – these nominal tape distances were left unchanged in the LUCAS database although plots were clearly unlikely to have been exactly 20 x 20 m when laid out on the slope. The calculated horizontal distance nevertheless provides a reasonable check of the measured (Vertex) horizontal distance (which sometimes resulted in smaller nominal slope corrected tape distances than measured horizontal distances eg plot BB110 – in this case the measured horizontal distance was retained). Where the horizontal distance was not measured, and the tape distance was a nominal

distance, then the slope corrected plot area is a nominal area (for example plot AU139).

- Tape distance was apparently (based on significant digits recorded) derived from measured horizontal distance and slope. Tape distances that appeared to have been derived from the horizontal distance should be replaced with nominal tape distances. Some examples of this were apparent.
- Directly measured horizontal distance exceeded the slope corrected tape distance. Data entry errors (in tape distance, slope angle, horizontal distance) were corrected, and measurement errors were flagged. Measured horizontal distances were used in all cases except for 15 plots where, due to measurement errors or omissions, the tape distance and slope measurements were considered to be superior (CL55, DQ53, AJ134, BA121, CB73, CO96, AB146, AB154, AW125, CW84, AU138, AU139, CJ66, DN58, and DX53.).
- Erroneous amalgamation of line sections invalidates data checks. Tape distances were often measured in sections to take account of changes in slope. Amalgamation of line sections by averaging or otherwise altering the actual measurements had occurred, and the amalgamated data entered. A line by line inspection of PDF files was necessary to locate this issue.
- Unavoidable measurement errors. Tapes may need to go over or around large logs, rocks and other obstructions along the plot margin. In such cases slope corrected tape distances will not be as accurate as horizontal distances measured with a Vertex. These possible errors were avoided by using the Vertex horizontal distances for all plots apart from those with obvious horizontal distance measurement errors.
- Measurements missed due to data entry errors. Distance and slope measurements were sometimes not entered for a plot. In other cases all data for a plot had not been entered. Records were inserted in Scion's version of the table.
- Distance, either of horizontal or slope corrected tape distance exceeded 22 m. Every instance was checked by comparing with PDF's.
- Distance ratio varied with slope. The ratio between the directly measured horizontal distance and the slope corrected tape distance was calculated by line section and the resulting ratios graphed with respect to the recorded slope. The graph was expected to be flat. Where trends (either increasing or decreasing with respect to slope) were evident, the data were checked. This check mostly located errors where the slope was not correctly matched with the tape distance, which arose frequently and was due to data entry errors.

A number of alterations to the data recorded on the field sheets have been made during/following data entry. Many of these changes were prompted by how data had been measured and recorded in the field, while other changes did not appear to have any obvious justification. To what extent all the errors have been picked up is uncertain. After applying corrections to the data, horizontal areas derived from tape distances and slopes on average overestimated plot areas by 2.6% relative to horizontal areas obtained using a Vertex (Fig. A1). This report is mostly based on horizontal areas calculated from horizontal distance measurements obtained with a Vertex, which can be expected to be reasonably unbiased. After corrections were applied to the data, 92 plots differing by >10% and 4 plots by >20% from horizontal areas calculated from slope-corrected tape distances, while 15 plots were not measured using a Vertex so the calculated plot area could not be checked.

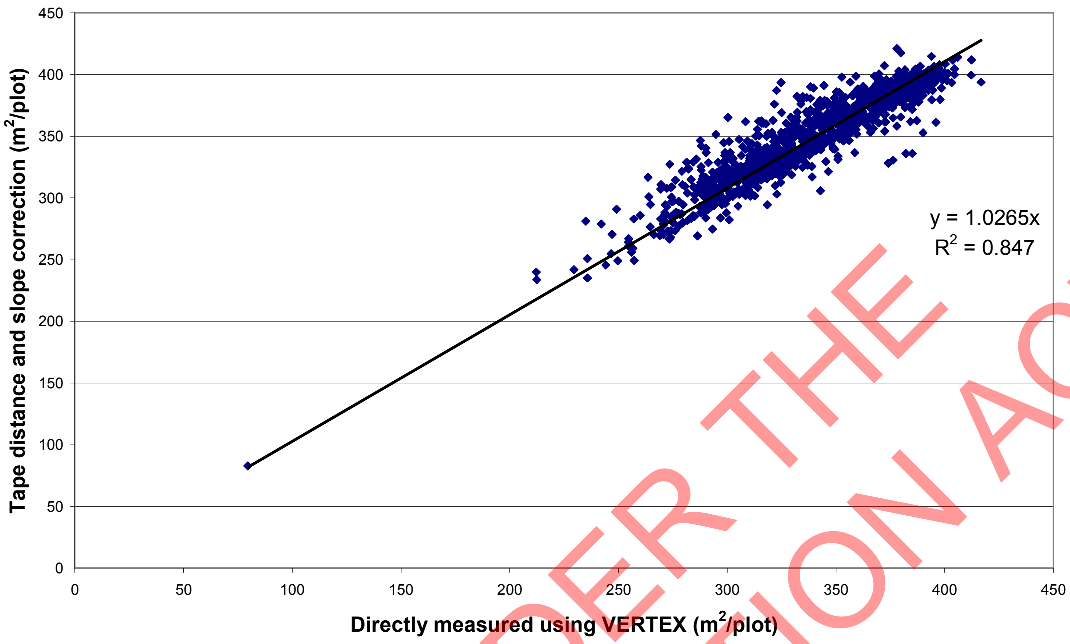

Fig. A1. Comparison of plot horizontal areas derived from side lengths, where side lengths were either directly measured (Vertex) horizontal distances or slope corrected tape distances.

Probable errors in 20 m radius circular external plot

A circular external plot of 20 m horizontal radius was used to measure all trees greater than 60 cm DBH and all CWD greater than 60 cm in diameter. According to the plot measurement manual, all trees and CWD greater than 60 cm diameter within a horizontal distance of 20 m from the plot centre were to be identified and measured. One means of checking whether this was carried out correctly is to calculate the stockings of live trees greater than 60 cm DBH in the internal and external plots which should not differ significantly. In practice, however, the stocking was 24.0±1.6 stems/ha (95% CI) in the circular plots and 30.6±2.5 stems/ha in the internal plots, a statistically highly significant difference. Further analysis indicated that the discrepancy was closely associated with the mean slope as measured in the internal plot (Fig. A2). On flat sites, the discrepancy was minor or absent but on steep sites it was considerable. For example, on plots with a slope greater than 25°, the stocking in the external plot was 30% less than in the internal plot. The difference was equally apparent in both North and South Island data.

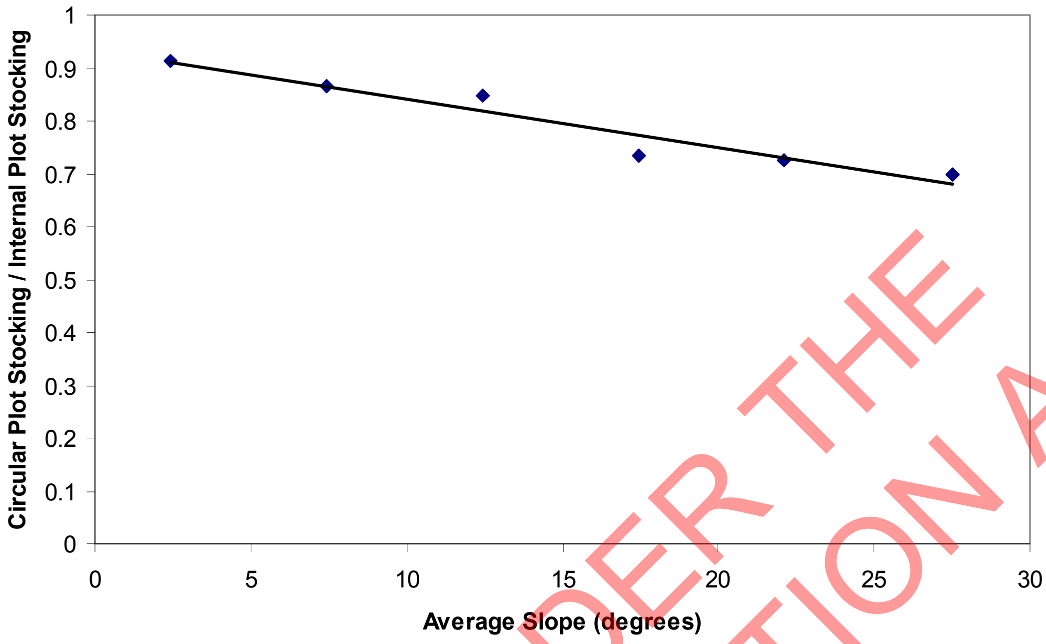

Fig. A2. Ratio of stocking of stems over 60 cm DBH in circular plot to internal plot versus average slope.

This discrepancy must be due either to plot area errors of either the internal or external plots, or to significant numbers of trees being missed within the external plot. Because areas of internal plots were calculated and compared using two different methods, it is unlikely that they have systematic errors sufficiently large to explain this result. The most likely explanation is that significant numbers of large trees within the 20 m radius plot were not measured. A tree will appear to be further away when looking up or down the slope than when looking predominantly along the contour. The distance to trees from the centre of the plot may not have been judged sufficiently well to reflect the slope on steep sites (i.e., the horizontal area of the plot was effectively smaller than intended), or simply that a proportion of large trees were overlooked. On average, 3 large live trees were recorded in each plot, 1 in the internal plot and the other 2 in the remainder of the external plot. However, to be consistent with the internal plot stocking, 2.7 live trees should have been recorded in this external area. In other words, 1 tree in 4 was missed within the external area. If live trees were missed, it is also possible that CWD logs will also have been missed.

The overall effect of this error is that carbon estimates are likely to have been underestimated. Some idea of its likely magnitude can be obtained by comparing carbon pools calculated using only the 20 x 20 m internal plot with estimates from the combined internal and circular plots as shown in Table A1. Estimates of total carbon and of carbon in AGB and BGB are about 9% higher, and of CWD about 13% higher, when only internal plots are used in the calculation. Note, however, that standard errors of internal plot estimates are much larger. Based on current information, the external plots have doubled the effective sample size but at the likely cost of significant bias in the final total. Clearly this is a serious error which must be understood and corrected during plot remeasurement.

Table A1.
Total carbon stocks (Mt) based on measurements from both internal and external plots, and on internal 20 x 20 m plots only.

Source	External + Internal plots		Internal plot	
	total	**s.e.**	**total**	**s.e.**
AGB (Mt)	988.6	18.6	1,076.6	26.0
BGB (Mt)	247.2	4.7	269.1	6.5
CWD (Mt)	131.3	4.1	148.1	5.5
FD (Mt)	171.9	14.5	171.9	14.5
Total (Mt)	1,538.9	28.1	1,665.6	36.7

Table 510_Survey for checking whether plots were abandoned
Variable T510_PlotAbandoned notes abandoned plots, according to the database.
Plot AT127 was noted as abandoned but classified as Shrub but noted as bare ground according to field crew classification
DL57 was noted as forest and mapped as forest by LCDB1.
These two plots were retained for carbon stock calculation purposes.

Table 520_IFReece (miss-spelt) for checking whether classification is correct
The observed classification, t520_LCBD1Observed is recorded, but the nominal LCBD1 classification (Shrub or Indigenous forest) does not appear to be included in this table, but probably should be.
Plot DD78 was classified by LCDB1 as planted forest and is planted forest – it should not have been sampled.
Twelve plots were apparently off the 8 km grid and ended up outside the mapped LCDB1 area based on the GPS coordinates, some of which were grassland, but also including one NVS plot which was obviously natural forest. These plots were all included for carbon stock calculation purposes.

The LCDB1 class for plot AI166 was correctly classified as shrubland, but the observed class was incorrectly entered as forest, and entered as indigenous forest on the database.

Tables relating to the L, FH(O) error checking procedures for the soil dataset
The natural forests soil data set can be divided into three sections; 1) plot level information, 2) soil sampling site level information, and 3) soil sample laboratory information (Garrett, 2009). For 331 plots all relevant fields needed to calculate carbon content for all sample types (FWD, L, FH(O)) were checked and entered where necessary. Where no value was present on the field sheet no value was entered and a comment was made.

The minimum information required for each measurement record consists of the plot LabID, CMSID, SampleTypeID, Total Bulked Sample (identification of the sample analysed per quarter in the laboratory), Quarter (quarters within the sample), and C%, LFH (g), Gravel (g) (for calculation of mass of carbon), and Quarter No., Quadrat Square No., Total Area (m^2) (the total area over which the sample was collected). FH sample type required FH measured depth (mm) in addition to the above fields to enable the calculation of FH bulk density to use in Equation 27.

Soils plots and samples that were abandoned

Plots with insufficient detail to calculate carbon stocks for any sample type were abandoned. From all plots, excluding the first sampling year the following 5 plots were immediately abandoned for all sample types for the reasons listed below:

- AX119, AY113, BG105, BG108 – no field summary sheets.
- AT127 –Plot was a scree slope covered in snow. No sample analysed in lab however described on field sheet as having 'one 10 cm core taken' therefore it was assumed that soil was present.

A further two plots were abandoned for soil samples (L169 and M158) due to incorrect sampling procedures in the field and L196 was abandoned for FH(O). Both of these plots were Organic Soils.

A tally of samples abandoned due to various reasons is given below, together with a tally by sample types of plots abandoned. Where a sample was abandoned no area was allocated and the sample area was removed from the carbon stock calculation.

The number of abandoned samples and the number of abandoned plots where forest floor material was either not collected or not usable for reasons given.			
Reason abandoned	Litter	FH(O)	Description
flower garden on residential property	1	1	One example CH41 – One quarter was within a flower garden on a residential property.
incorrect sampling		43	FH – sampled moved to 'O' horizon (Q157, S149) FH – not sampled to total depth
lost sample		2	Sample collected, however, not submitted to the lab
obstruction		2	Obstruction to sampling soil that is present, ie large coarse woody debris, roots and rocks
sample on road		1	Sample on a road (BE113)
snow covered scree slope	4	4	Plot covered in snow – dominantly scree slope (AT127)
swamp		3	Three quarters of plot CH44 located in a swamp
time	70	139	Limited time on the plot not sampled
Total number of samples abandoned	75	199	
Total number of plots where sample type is abandoned	0	11	

A total of 11 plots were abandoned for the FH sample type. The main reason (excluding time) was incorrect sampling. This resulted where the FH or FH(O) was not sampled to the full depth of the sample type and only a 10 cm depth core was taken. Where this occurred all of the sample type from all quarters was abandoned.

In four plots, the sampling area recorded for a quadrat differed from 0.1 m^2 for FH (Table 3). The two samples in T147 were abandoned as the sample was analysed by individual quarter in the lab, the other samples were bulked by plot and were retained.

Sampling areas for quadrat that vary from standard 0.1m2 quadrat.			
CMSID	Quarter	SampleType	Comment
H161	a	FH	Check area of quadrat - have assumed 0.1m2 (written on sheet Volume = 30cm x 26cm x 4 cm)
H161	p	FH	Check area of quadrat - have assumed 0.1m2 (written on sheet Volume = 26cm x 28cm x 4 cm)
L170	m	FH	Check area of quadrat - have assumed 0.1m2 (written on sheet Volume = 27cm x 25cm x 4 cm)
T147	d	FH	Check area of quadrat - have assumed 0.1m2 (written on sheet Volume = 27cm x 25cm x 5 cm). Abandoned.
T147	m	FH	Check area of quadrat - have assumed 0.1m2 (written on sheet Volume = 27cm x 25cm x 5 cm). Abandoned.
V161	a	FH	Check area of quadrat - have assumed 0.1m2 (written on sheet Volume = 25cm x 25cm x 6 cm)
V161	d	FH	Check area of quadrat - have assumed 0.1m2 (written on sheet Volume = 23cm x 14cm x 4 cm)

Table FWD error checking procedures for the soil dataset
Measurements of FWD in soil plots are contained in the FWD table. There are 760 records in the table, each representing the measurement FWD mass and collection area at each plot quarter.

The minimum information required for each measurement record consists of the plot CMS ID, Quarter, SampleCollected (which was used to remove quarters that were abandoned for a variety of reason), Drywt (g), and CollectionArea(m^2) (used to calculate mass per hectare).

Likely database errors were identified through range checks and correlation with samples (collected or not collected), and these were checked against PDFs of the original plot sheets, and errors corrected.

Table PlotSlopeArea error checking procedures for the soil LUCAS dataset
Measurements of individual slope per sampling site are contained in the PlotSlopeArea table. There are 4,596 records in the table, each representing the slope measurement at each FWD and LFH(O) sampling site.

The minimum information required for each measurement record consists of the plot CMS ID, Quarter, Slope Name (a slope measurement for each individual quadrat), No Slope, and Reason for no slope (to allow for the allocation of a slope value or not, ie 'not measured' or 'time'), and SlopeAll (used for calculations).

Likely database errors were identified using range checks, and these were checked against PDFs of the original plot sheets, and errors corrected.

Table t520_Plot reece error checking procedures for the soil LUCAS dataset
Measurements of average plot slope are contained in Table t520 in the LUCAS database. There are 1,644 records in the table, each representing the measurements of average plot slope. Only plot slope measurements from the LUCAS data collection set were used and historical NVS plot slope measurements, also in data set, were not used.

The average plot slope from the reece sheet was used for all soil plots as this slope was based on the vertex measurements along the plot boundaries and all plots have this measurement. The average plot slope on the soil field sheet was not used for the following reasons; for Scion collected plots the plot slope was the average of the measured slopes at each individual litter square and for Landcare collected plots correlation with the average plot slope in the 'original data' with average plot slope on the reece sheet showed some differences.

The minimum information required for each measurement record consists of the plot CMS ID and Slope. Soil plots were filtered out of the dataset resulting in a total of 361 plots that were checked.

Likely database errors were identified using range checks, and these were checked against PDFs of the original plot sheets.

Summary of checks for soil plots only:

- Average plot slope for soil plots had been miss-punched for two plots and three plots have no value, as listed below. One was recorded as a negative number and in the other the aspect and slope of the plot were entered in reverse.

t520_CMSID	Database Value	Correction required	Variable	Comment
DR56	-17	17	t520_Slope	
DS60	85	7	t520_Slope	85 = aspect of plot
CA74			t520_Slope	Missing plot slope value
AS147			t520_Slope	Missing plot slope value
BL125			t520_Slope	Missing plot slope value
DS60	7	85	T520_Aspect	7 = slope of plot

Appendix 2. Carbon stock estimates and other information for each LUCAS plot

CMSID	Inner Plot Area (m^2)	Modified EcoSat Type	Region	AGB (t/ha)	BGB (t/ha)	CWD (t/ha)	FWD (t/ha)	Litter (t/ha)	FH(O) (t/ha)	Stem Volume (m^3/ha)
AA138	382	Podocarp	West C.	9.4	2.3	7.6	.	.	.	23.4
AA139	389	Pod/Brdlf	West C.	486.2	121.5	14.6	.	.	.	1859.1
AA140	335	Unsp Indg	West C.	0.0	0.0	0.0	.	.	.	0.0
AA142	299	SubalpShrub	West C.	11.5	2.9	1.3	.	2.3	.	24.4
AA160	276	Other Shrub	Southland	0.0	0.0	0.0	.	.	.	0.0
AB138	399	Podocarp	West C.	189.6	47.4	18.4	.	.	.	772.3
AB139	299	Bch/Pod/Brdlf	West C.	165.2	41.3	7.8	.	6.4	7.1	479.5
AB143	348	Beech	Otago	153.6	38.4	72.0	.	4.5	22.6	551.6
AB144	388	Beech	Otago	125.6	31.4	38.9	.	.	.	449.0
AB146	393	Other Shrub	Otago	2.2	0.6	0.0	.	.	.	4.7
AB154	366	Other Shrub	Otago	2.7	0.7	0.0	.	0.9	2.6	5.8
AB161	305	Beech	Southland	209.4	52.4	22.1	.	.	.	762.5
AB163	343	Unsp Indg	Southland	225.0	56.3	11.9	.	.	.	799.8
AB168	380	Other Shrub	Southland	8.8	2.2	1.4	.	.	.	17.3
AC136	395	Pod/Brdlf	West C.	203.1	50.8	4.0	.	.	.	807.1
AC137	397	Pod/Brdlf	West C.	258.8	64.7	30.3	.	.	.	1057.2
AC138	242	Beech	West C.	72.6	18.1	15.0	.	.	.	232.3
AC140	315	Beech	West C.	63.9	16.0	45.5	.	.	.	200.7
AC141	345	Beech	Otago	187.5	46.9	21.4	.	.	.	678.3
AC149	272	Other Shrub	Otago	0.3	0.1	0.0	.	.	.	0.5
AC153	331	Other Shrub	Otago	0.2	0.0	0.3	.	0.9	0.0	0.3
AC160	347	Beech	Southland	249.3	62.3	14.0	.	3.8	21.3	885.8
AC161	331	Beech	Southland	290.3	72.6	14.4	.	.	.	1038.3
AC173	360	Pod/Brdlf	Southland	306.8	76.7	30.5	.	.	.	860.9
AD136	272	Other Shrub	West C.	56.3	14.1	4.4	.	.	.	165.6
AD138	355	Beech	West C.	67.8	16.9	0.1	.	2.6	0.0	222.8
AD139	292	Beech	West C.	218.2	54.6	18.6	.	3.8	5.4	726.7
AD141	293	Beech	Otago	145.4	36.3	9.1	.	3.0	15.8	450.0
AD142	300	Beech	Otago	141.1	35.3	21.1	.	.	.	473.9
AD153	361	Other Shrub	Otago	0.1	0.0	0.0	.	0.8	0.0	0.2
AD172	311	Unsp Indg	Southland	213.9	53.5	53.8	.	.	.	554.6
AD174	394	Other Shrub	Southland	0.1	0.0	0.0	.	.	.	0.2
AD175	372	Pod/Brdlf	Southland	432.1	108.0	36.6	.	.	.	1207.8
AE136	274	Pod/Brdlf	West C.	55.4	13.8	46.6	.	4.1	0.0	212.4
AE137	344	Beech	West C.	191.0	47.8	35.3	.	.	.	625.1
AE141	328	Beech	Otago	196.8	49.2	14.1	.	.	.	699.0
AE142	291	Beech	Otago	146.2	36.5	24.0	.	.	.	471.9
AE145	294	Beech	Otago	91.2	22.8	8.7	.	4.0	2.7	295.3
AE173	339	Pod/Brdlf	Southland	139.7	34.9	33.3	.	.	.	439.0
AF134	362	Pod/Brdlf	West C.	163.9	41.0	10.3	.	.	.	554.2
AF135	394	Pod/Brdlf	West C.	70.6	17.7	12.0	.	1.8	3.1	243.4
AF149	314	Other Shrub	Otago	0.0	0.0	0.0	.	1.2	0.4	0.0
AF155	384	Other Shrub	Otago	0.8	0.2	0.0	.	0.8	0.0	1.6
AF156	395	Other Shrub	Otago	157.0	39.3	0.0	.	.	.	608.2
AF166	328	Beech	Otago	171.5	42.9	5.2	.	.	.	545.3
AF167	350	Beech	Otago	92.2	23.1	2.4	.	.	.	316.9
AF173	381	Pod/Brdlv/Bch	Otago	102.3	25.6	0.8	.	.	.	223.8
AG134	313	Podocarp	West C.	108.1	27.0	22.2	.	3.6	28.9	369.2

CMSID	Inner Plot Area (m^2)	Modified EcoSat Type	Region	AGB (t/ha)	BGB (t/ha)	CWD (t/ha)	FWD (t/ha)	Litter (t/ha)	FH(O) (t/ha)	Stem Volume (m^3/ha)
AG135	298	Broadleaf	West C.	208.1	52.0	47.4	.	.	.	556.3
AG136	275	Beech	West C.	230.1	57.5	24.0	.	.	.	795.9
AG138	366	Beech	West C.	242.0	60.5	32.2	.	.	.	844.9
AG140	281	Beech	Otago	3.2	0.8	0.0	.	6.4	1.3	5.7
AG144	348	Beech	Otago	133.5	33.4	24.0	.	.	.	429.5
AG145	316	Beech	Otago	75.4	18.9	7.1	.	.	.	209.2
AG147	348	Beech	Otago	120.6	30.1	13.2	.	.	.	368.9
AG166	378	Beech	Otago	169.2	42.3	9.1	.	.	.	617.8
AG173	326	Bch/Pod/Brdlf	Otago	183.9	46.0	60.5	.	.	.	606.9
AG175	377	Pod/Brdlf	Otago	249.3	62.3	9.1	.	.	.	849.2
AH133	391	Pod/Brdlf	West C.	322.8	80.7	11.8	.	.	.	1224.4
AH134	316	Pod/Brdlf	West C.	30.5	7.6	4.0	.	.	.	214.4
AH135	362	Broadleaf	West C.	52.4	13.1	5.4	.	.	.	227.1
AH136	343	SubalpShrub	West C.	27.3	6.8	0.6	.	.	.	72.9
AH138	306	Beech	West C.	103.0	25.8	61.8	.	.	.	375.9
AH140	330	Beech	Otago	213.1	53.3	26.1	.	.	.	736.2
AH166	379	Other Shrub	Otago	0.0	0.0	0.0	.	.	.	0.0
AI133	359	Podocarp	West C.	259.9	65.0	22.1	.	.	.	955.8
AI136	355	Other Shrub	West C.	0.0	0.0	0.0	.	.	.	0.0
AI137	390	Beech	West C.	154.0	38.5	8.7	.	.	.	520.7
AI166	398	Other Shrub	Otago	20.2	5.1	0.0	.	0.7	0.0	85.5
AI172	367	Pod/Brdlf	Otago	314.9	78.7	39.7	.	.	.	834.5
AJ131	403	Podocarp	West C.	154.6	38.7	13.9	.	.	.	564.7
AJ132	412	Unsp Indg	West C.	79.3	19.8	20.4	.	.	.	328.8
AJ133	310	Broadleaf	West C.	248.6	62.2	70.1	.	.	.	562.4
AJ134	375	Broadleaf	West C.	479.2	119.8	57.5	.	.	.	1198.2
AJ135	321	SubalpShrub	West C.	4.5	1.1	1.3	.	.	.	10.3
AJ145	349	Other Shrub	Otago	0.0	0.0	0.0	.	0.6	0.0	0.0
AJ149	318	Other Shrub	Otago	0.0	0.0	0.0	.	.	.	0.0
AJ156	337	Other Shrub	Otago	0.0	0.0	0.0	.	0.8	0.2	0.0
AK131	350	Pod/Brdlf	West C.	239.2	59.8	27.7	.	.	.	718.0
AK134	280	Broadleaf	West C.	162.8	40.7	34.8	.	.	.	429.1
AK138	329	Other Shrub	Canterbury	25.4	6.4	21.3	.	.	.	80.3
AK139	389	Other Shrub	Canterbury	7.4	1.9	0.0	.	.	.	15.1
AK157	362	Other Shrub	Otago	0.0	0.0	0.0	.	0.6	0.3	0.0
AK166	368	Other Shrub	Otago	0.0	0.0	0.0	.	0.0	0.0	0.0
AL129	307	Other Shrub	West C.	20.5	5.1	0.0	.	.	.	74.0
AL130	395	Pod/Brdlf	West C.	146.9	36.7	6.9	.	.	.	628.4
AL131	369	Pod/Brdlf	West C.	302.6	75.6	23.9	.	.	.	927.8
AM129	370	Podocarp	West C.	121.1	30.3	13.0	.	.	.	472.5
AM131	303	Broadleaf	West C.	193.4	48.3	1.2	.	.	.	410.2
AM135	322	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0
AM143	383	Other Shrub	Canterbury	1.5	0.4	0.0	.	.	.	4.9
AM145	326	Other Shrub	Otago	0.0	0.0	0.0	.	1.0	0.0	0.0
AM146	307	Other Shrub	Otago	0.0	0.0	0.0	.	.	.	0.0
AM157	363	Other Shrub	Otago	0.0	0.0	0.0	.	.	.	0.0
AN127	397	Podocarp	West C.	100.0	25.0	1.9	.	0.8	20.8	342.6
AN128	390	Podocarp	West C.	182.8	45.7	13.9	.	.	.	672.7
AN129	300	Pod/Brdlf	West C.	332.8	83.2	40.9	.	.	.	1044.1
AN131	302	Broadleaf	West C.	69.0	17.2	103.2	.	.	.	188.7

CMSID	Inner Plot Area (m^2)	Modified EcoSat Type	Region	AGB (t/ha)	BGB (t/ha)	CWD (t/ha)	FWD (t/ha)	Litter (t/ha)	FH(O) (t/ha)	Stem Volume (m^3/ha)
AN158	358	Other Shrub	Otago	0.0	0.0	0.0	.	.	.	0.0
AO127	400	Podocarp	West C.	68.8	17.2	20.2	.	.	.	231.6
AO129	345	Pod/Brdlf	West C.	112.7	28.2	22.9	.	.	.	410.6
AO138	396	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0
AO143	397	Other Shrub	Canterbury	0.0	0.0	0.4	.	.	.	0.0
AP127	343	Pod/Brdlf	West C.	162.2	40.6	14.3	.	.	.	576.3
AP128	378	Pod/Brdlf	West C.	196.8	49.2	21.8	.	.	.	703.7
AP130	340	Pod/Brdlf	West C.	172.7	43.2	43.5	.	.	.	564.0
AP147	329	Other Shrub	Canterbury	0.0	0.0	0.0	.	0.4	0.0	0.0
AP148	394	Other Shrub	Canterbury	0.0	0.0	0.0	.	0.5	0.0	0.0
AP155	381	Other Shrub	Otago	0.0	0.0	0.0	.	1.0	0.0	0.0
AP160	392	Other Shrub	Otago	0.0	0.0	0.0	.	.	.	0.0
AQ125	380	Podocarp	West C.	55.4	13.8	30.5	.	.	.	213.2
AQ163	309	Other Shrub	Otago	0.0	0.0	1.5	.	5.8	4.1	0.0
AQ164	388	Other Shrub	Otago	13.2	3.3	0.3	.	.	.	38.0
AR125	395	Pod/Brdlf	West C.	60.0	15.0	49.7	.	.	.	220.5
AR126	304	SubalpShrub	West C.	250.2	62.5	19.1	.	.	.	546.2
AR127	290	SubalpShrub	West C.	37.0	9.3	1.2	.	.	.	97.6
AR128	303	SubalpShrub	West C.	7.9	2.0	0.0	.	.	.	14.9
AR161	329	Other Shrub	Otago	33.7	8.4	0.5	.	.	.	71.2
AR164	357	Other Shrub	Otago	30.8	7.7	9.8	.	.	.	69.1
AS125	388	Pod/Brdlf	West C.	103.2	25.8	8.9	.	.	.	268.3
AS126	212	Pod/Brdlf	West C.	32.3	8.1	1.7	.	3.4	1.7	115.5
AS127	274	Broadleaf	West C.	84.0	21.0	45.3	.	.	.	236.3
AS128	375	Broadleaf	West C.	91.0	22.7	5.7	.	.	.	409.0
AS147	323	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0
AS156	340	Other Shrub	Otago	59.0	14.7	10.6	.	.	.	161.6
AS165	360	Other Shrub	Otago	2.7	0.7	0.0	.	4.0	1.9	5.4
AT123	388	Other Shrub	West C.	1.3	0.3	1.0	.	.	.	2.7
AT124	362	Pod/Brdlf	West C.	9.4	2.4	9.1	.	.	.	21.6
AT127	367	Unsp Indg	West C.	0.0	0.0	0.0	.	.	.	0.0
AT131	356	Other Shrub	Canterbury	0.0	0.0	0.0	.	1.2	2.4	0.0
AT133	312	Beech	Canterbury	93.6	23.4	4.4	.	9.8	7.4	271.0
AT157	371	Unsp Indg	Otago	86.6	21.6	6.4	.	.	.	213.1
AU122	368	Podocarp	West C.	14.0	3.5	1.2	.	.	.	36.8
AU124	332	Pod/Brdlf	West C.	192.3	48.1	38.9	.	.	.	642.5
AU125	331	Pod/Brdlf	West C.	166.9	41.7	22.8	.	4.8	13.1	550.5
AU126	290	Pod/Brdlf	West C.	0.0	0.0	0.0	.	.	.	0.0
AU138	335	Other Shrub	Canterbury	0.0	0.0	0.0	.	0.1	0.0	0.0
AU139	371	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0
AU142	352	Other Shrub	Canterbury	0.0	0.0	0.0	.	5.5	0.0	0.0
AU145	336	Other Shrub	Canterbury	0.0	0.0	0.0	.	9.1	1.5	0.0
AU146	308	Other Shrub	Canterbury	72.7	18.2	0.8	.	9.1	4.5	189.5
AU148	356	Other Shrub	Canterbury	0.0	0.0	0.0	.	0.3	0.0	0.0
AV122	335	Pod/Brdlf	West C.	31.6	7.9	7.0	.	.	.	157.8
AV124	301	Pod/Brdlf	West C.	205.7	51.4	17.9	.	3.7	6.6	655.8
AV125	299	Broadleaf	West C.	265.2	66.3	14.0	.	4.4	10.3	698.6
AV126	378	Pod/Brdlf	West C.	6.8	1.7	0.0	.	.	.	14.9
AV129	287	Other Shrub	Canterbury	0.0	0.0	0.0	.	2.6	5.8	0.0
AV139	338	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0

CMSID	Inner Plot Area (m^2)	Modified EcoSat Type	Region	AGB (t/ha)	BGB (t/ha)	CWD (t/ha)	FWD (t/ha)	Litter (t/ha)	FH(O) (t/ha)	Stem Volume (m^3/ha)
AW118	339	Other Shrub	West C.	43.5	10.9	15.1	.	.	.	197.5
AW120	388	Pod/Brdlf	West C.	64.5	16.1	10.2	.	.	.	180.4
AW121	370	Pod/Brdlf	West C.	15.3	3.8	0.0	.	.	.	50.3
AW122	286	Podocarp	West C.	233.6	58.4	32.2	.	.	.	632.7
AW123	387	Broadleaf	West C.	100.9	25.2	4.1	.	2.2	0.4	433.3
AW124	305	Broadleaf	West C.	161.0	40.2	50.8	.	.	.	476.9
AW125	229	Pod/Brdlf	West C.	11.3	2.8	0.0	.	.	.	28.5
AW128	269	Other Shrub	Canterbury	0.0	0.0	0.0	.	5.1	2.1	0.0
AW139	393	Planted	Canterbury	107.3	26.8	15.2	.	.	.	348.3
AX116	364	Other Shrub	West C.	0.0	0.0	0.0	.	.	.	0.0
AX118	321	Pod/Brdlf	West C.	200.9	50.2	17.1	.	.	.	655.2
AX119	393	Other Shrub	West C.	19.7	4.9	36.2	.	.	.	57.0
AX120	342	Broadleaf	West C.	91.8	23.0	22.6	.	.	.	329.6
AX121	374	Broadleaf	West C.	61.7	15.4	9.2	.	1.9	0.0	280.3
AX122	391	Broadleaf	West C.	64.2	16.0	12.3	.	.	.	175.7
AX123	257	SubalpShrub	West C.	8.4	2.1	2.1	.	.	.	19.9
AX124	319	Broadleaf	West C.	79.5	19.9	58.4	.	.	.	295.2
AX125	288	Unsp Indg	Canterbury	0.0	0.0	0.0	.	.	.	0.0
AX127	293	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0
AX128	365	Other Shrub	Canterbury	0.9	0.2	0.0	.	.	.	1.6
AX137	373	Other Shrub	Canterbury	98.3	24.6	1.1	.	1.2	0.0	241.4
AY112	390	Pod/Brdlv/Bch	West C.	335.5	83.9	15.7	.	.	.	1184.2
AY113	321	Pod/Brdlf	West C.	23.6	5.9	8.1	.	.	.	151.7
AY114	296	Beech	West C.	156.3	39.1	31.5	.	.	.	552.2
AY116	353	Bch/Pod/Brdlf	West C.	294.6	73.7	23.8	.	.	.	1077.4
AY118	312	Pod/Brdlv/Bch	West C.	117.7	29.4	36.8	.	.	.	341.6
AY119	372	Broadleaf	West C.	101.4	25.4	30.4	.	.	.	269.0
AY120	370	Broadleaf	West C.	158.7	39.7	16.2	.	.	.	615.2
AY121	313	Broadleaf	West C.	150.5	37.6	28.4	.	3.7	1.1	354.7
AY122	373	Other Shrub	West C.	0.0	0.0	0.0	.	1.1	7.7	0.0
AY123	352	Other Shrub	West C.	89.4	22.3	9.1	.	.	.	226.4
AY127	299	Other Shrub	Canterbury	15.4	3.8	0.0	.	.	.	37.6
AY128	338	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0
AZ109	392	Other Shrub	West C.	62.4	15.6	1.8	.	.	.	183.5
AZ110	393	Pod/Brdlv/Bch	West C.	129.0	32.3	5.9	.	2.0	1.2	546.0
AZ112	367	Pod/Brdlv/Bch	West C.	170.8	42.7	8.8	.	2.1	16.2	632.0
AZ113	317	Bch/Pod/Brdlf	West C.	129.8	32.4	15.0	.	.	.	361.4
AZ114	284	Beech	West C.	251.6	62.9	40.6	.	.	.	958.5
AZ115	322	Other Shrub	West C.	76.2	19.0	26.6	.	.	.	273.4
AZ116	318	Unsp Indg	West C.	79.3	19.8	58.0	.	.	.	293.2
AZ117	383	Pod/Brdlv/Bch	West C.	138.4	34.6	4.5	.	.	.	484.7
AZ118	417	Pod/Brdlf	West C.	107.3	26.8	34.1	.	6.0	103.7	343.8
AZ120	343	Pod/Brdlf	West C.	60.6	15.2	43.1	.	.	.	297.7
AZ122	345	Broadleaf	West C.	216.0	54.0	21.3	.	.	.	641.2
AZ124	294	Beech	Canterbury	124.6	31.2	12.5	.	.	.	355.2
AZ132	290	Other Shrub	Canterbury	2.5	0.6	0.0	.	1.0	0.0	5.4
AZ133	361	Beech	Canterbury	72.4	18.1	11.5	.	.	.	223.2
BA109	299	Pod/Brdlv/Bch	West C.	68.1	17.0	22.6	.	.	.	210.3
BA110	295	Pod/Brdlv/Bch	West C.	189.9	47.5	15.9	.	.	.	577.5
BA111	257	Beech	West C.	140.8	35.2	4.3	.	.	.	366.7

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BA112	282	Beech	West C.	213.9	53.5	9.0	.	.	.	675.8
BA113	361	Beech	West C.	157.9	39.5	40.6	.	.	.	544.2
BA118	368	Pod/Brdlf	West C.	136.8	34.2	14.3	.	3.8	49.5	425.6
BA119	384	Pod/Brdlf	West C.	167.2	41.8	18.2	.	.	.	564.1
BA121	348	Beech	West C.	505.8	126.5	65.5	.	.	.	1364.4
BA122	272	Pod/Brdlv/Bch	West C.	285.5	71.4	10.7	.	.	.	704.7
BA123	301	Other Shrub	West C.	48.0	12.0	0.3	.	8.0	27.1	127.8
BA124	318	Beech	Canterbury	81.4	20.4	6.3	.	2.6	6.3	267.9
BA125	369	Beech	Canterbury	108.0	27.0	3.6	.	.	.	310.7
BA132	247	SubalpShrub	Canterbury	180.6	45.2	2.9	.	.	.	443.9
BB108	373	Pod/Brdlv/Bch	West C.	56.0	14.0	3.8	.	.	.	171.4
BB109	339	Pod/Brdlv/Bch	West C.	218.9	54.7	23.3	.	.	.	646.3
BB110	394	Pod/Brdlv/Bch	West C.	192.9	48.2	31.1	.	.	.	705.9
BB111	284	Pod/Brdlv/Bch	West C.	6.4	1.6	2.5	.	2.5	8.7	13.5
BB112	332	Beech	West C.	229.2	57.3	34.3	.	.	.	790.3
BB114	405	Pod/Brdlv/Bch	West C.	0.0	0.0	3.4	.	0.6	0.0	0.0
BB115	359	Pod/Brdlv/Bch	West C.	69.6	17.4	3.2	.	1.9	.	227.1
BB116	353	Pod/Brdlv/Bch	West C.	159.8	39.9	35.0	.	6.0	61.0	528.2
BB118	393	Planted	West C.	99.1	24.8	8.0	.	.	.	384.4
BB119	399	Pod/Brdlv/Bch	West C.	111.2	27.8	21.1	.	5.5	0.0	366.4
BB124	328	Beech	Canterbury	80.2	20.1	22.5	.	.	.	233.8
BC107	362	Other Shrub	West C.	13.3	3.3	0.0	.	14.5	2.0	34.7
BC108	266	Beech	West C.	176.9	44.2	30.8	.	.	.	534.1
BC109	387	Bch/Pod/Brdlf	West C.	159.6	39.9	38.9	.	.	.	543.9
BC110	249	Pod/Brdlv/Bch	West C.	150.3	37.6	17.7	.	.	.	422.3
BC111	355	Pod/Brdlv/Bch	West C.	281.7	70.4	30.9	.	.	.	989.3
BC113	361	Pod/Brdlv/Bch	West C.	154.0	38.5	10.8	.	.	.	451.4
BC114	387	Other Shrub	West C.	0.5	0.1	0.0	.	1.2	0.5	1.2
BC116	362	Pod/Brdlv/Bch	West C.	184.7	46.2	31.7	.	.	.	575.0
BC117	313	Pod/Brdlv/Bch	West C.	131.4	32.9	23.1	.	.	.	439.0
BC118	389	Beech	West C.	47.7	11.9	0.3	.	.	.	138.0
BC119	359	Bch/Pod/Brdlf	West C.	267.2	66.8	30.5	.	.	.	903.5
BC120	340	Pod/Brdlf	West C.	249.5	62.4	33.1	.	6.6	9.8	641.8
BC121	400	Other Shrub	West C.	7.3	1.8	0.0	.	0.2	0.0	18.5
BC130	318	Beech	Canterbury	59.9	15.0	6.7	.	9.6	3.4	156.1
BD107	401	Other Shrub	West C.	8.0	2.0	1.2	.	.	.	14.2
BD108	257	Beech	West C.	173.6	43.4	26.5	.	.	.	573.1
BD109	352	Pod/Brdlv/Bch	West C.	114.5	28.6	54.8	.	3.4	13.3	400.7
BD110	398	Other Shrub	West C.	32.4	8.1	5.6	.	2.3	1.3	81.2
BD112	391	Unsp Indg	West C.	162.6	40.6	20.9	.	.	.	588.9
BD113	316	Bch/Pod/Brdlf	West C.	181.6	45.4	14.9	.	.	.	693.4
BD114	330	Bch/Pod/Brdlf	West C.	207.2	51.8	12.2	.	.	.	650.1
BD115	395	Pod/Brdlv/Bch	West C.	48.3	12.1	10.4	.	.	.	134.1
BD116	375	Bch/Pod/Brdlf	West C.	222.4	55.6	35.5	.	.	.	786.4
BD117	297	Beech	West C.	154.6	38.6	14.5	.	.	.	489.1
BD118	385	Beech	West C.	349.3	87.3	16.3	.	6.6	94.7	1278.3
BD119	269	Beech	West C.	108.2	27.1	5.4	.	.	.	301.5
BD121	300	Beech	Canterbury	214.6	53.7	11.0	.	.	.	722.5
BD123	388	Other Shrub	Canterbury	34.5	8.6	0.7	.	.	.	75.9
BE104	384	Pod/Brdlv/Bch	West C.	45.3	11.3	6.0	.	.	.	219.4

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BE105	399	Pod/Brdlv/Bch	West C.	66.0	16.5	3.7	.	.	.	213.3
BE106	346	Pod/Brdlv/Bch	West C.	130.5	32.6	19.1	.	.	.	410.1
BE107	375	Other Shrub	West C.	0.5	0.1	0.2	.	.	.	1.0
BE108	354	Pod/Brdlv/Bch	West C.	181.5	45.4	61.7	.	.	.	659.9
BE109	342	Bch/Brdlv	West C.	127.4	31.8	31.5	.	.	.	408.5
BE110	386	Bch/Pod/Brdlf	West C.	106.9	26.7	18.7	.	.	.	363.5
BE111	335	Bch/Pod/Brdlf	West C.	131.8	32.9	23.8	.	.	.	446.3
BE112	376	Bch/Pod/Brdlf	West C.	146.0	36.5	20.3	.	.	.	530.1
BE113	377	Other Shrub	West C.	0.0	0.0	0.0	.	0.0	0.0	0.0
BE114	389	Beech	West C.	111.4	27.9	99.9	.	3.0	5.2	409.3
BE115	343	Beech	West C.	181.1	45.3	71.7	.	.	.	645.0
BE117	305	Beech	West C.	123.5	30.9	21.9	.	.	.	383.0
BE119	354	Beech	West C.	61.5	15.4	4.8	.	.	.	163.0
BE123	387	Beech	Canterbury	91.0	22.8	36.7	.	4.8	.	308.1
BE124	294	Beech	Canterbury	28.5	7.1	0.2	.	.	.	74.3
BE129	312	Planted	Canterbury	211.8	52.9	0.6	.	.	.	804.7
BF103	396	Pod/Brdlf	West C.	168.5	42.1	5.0	.	.	.	544.5
BF104	304	Beech	West C.	139.9	35.0	14.7	2.6	4.4	13.2	472.6
BF106	335	Beech	West C.	188.4	47.1	15.0	.	.	.	617.1
BF107	300	Beech	West C.	22.7	5.7	55.8	.	1.9	0.4	285.9
BF109	349	Beech	West C.	194.4	48.6	22.0	.	.	.	617.0
BF110	300	Beech	Tasman	144.4	36.1	12.9	.	.	.	461.8
BF112	270	Bch/Pod/Brdlf	West C.	229.2	57.3	10.9	.	.	.	722.1
BF113	286	Beech	West C.	205.1	51.3	29.2	.	6.7	.	667.0
BF115	298	Beech	West C.	154.7	38.7	61.6	.	.	.	534.4
BF116	318	Beech	West C.	90.3	22.6	10.9	.	1.7	.	277.7
BF117	297	Beech	West C.	278.0	69.5	26.0	.	.	.	947.9
BF120	277	SubalpShrub	Canterbury	361.8	90.4	33.1	.	3.6	5.2	1287.9
BF121	338	Beech	Canterbury	174.7	43.7	12.9	.	4.0	19.0	590.7
BF125	310	Other Shrub	Canterbury	1.4	0.4	0.0	.	.	.	2.6
BF127	358	Beech	Canterbury	90.7	22.7	15.1	.	10.1	11.4	280.3
BF128	344	Beech	Canterbury	58.9	14.7	28.7	.	.	.	169.9
BF135	382	Planted	Canterbury	57.6	14.4	5.0	.	.	.	206.3
BG100	305	Pod/Brdlv/Bch	West C.	187.6	46.9	6.3	.	.	.	635.6
BG102	352	Pod/Brdlf	West C.	185.5	46.4	5.2	.	.	.	662.5
BG103	363	Bch/Pod/Brdlf	West C.	219.7	54.9	17.9	.	2.2	0.9	821.5
BG105	335	Pod/Brdlf	West C.	259.2	64.8	23.9	.	.	.	888.3
BG107	255	Beech	Tasman	227.5	56.9	15.9	.	.	.	773.8
BG108	380	Bch/Pod/Brdlf	Tasman	152.1	38.0	11.0	.	.	.	552.5
BG109	389	Beech	Tasman	114.9	28.7	47.5	.	.	.	417.3
BG110	347	Beech	Tasman	332.5	83.1	9.3	.	.	.	1180.8
BG111	274	Beech	Tasman	193.8	48.4	30.8	.	.	.	664.5
BG112	338	Beech	Tasman	148.1	37.0	25.7	.	4.2	4.8	445.8
BG114	326	Beech	West C.	227.8	57.0	41.3	.	.	.	807.4
BG115	271	Beech	West C.	199.4	49.9	31.4	.	4.7	.	668.2
BG116	412	Beech	West C.	128.0	32.0	24.3	.	.	.	455.2
BG118	312	Beech	Canterbury	348.4	87.1	17.6	.	.	.	1246.3
BG121	293	Beech	Canterbury	208.8	52.2	30.0	.	.	.	743.8
BG122	371	Beech	Canterbury	178.0	44.5	10.8	.	.	.	595.5
BG123	361	Beech	Canterbury	137.3	34.3	9.2	.	.	.	388.5

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BG124	346	Unsp Indg	Canterbury	83.2	20.8	12.3	.	9.7	9.8	253.5
BG125	330	Beech	Canterbury	134.8	33.7	5.0	.	.	.	327.0
BG136	398	Other Shrub	Canterbury	0.7	0.2	0.0	.	.	.	1.3
BG95	338	Broadleaf	West C.	189.3	47.3	30.4	.	.	.	549.4
BG97	350	Pod/Brdlv/Bch	West C.	63.3	15.8	1.3	0.8	4.2	9.5	119.1
BG98	335	Bch/Pod/Brdlf	West C.	143.8	36.0	32.6	0.1	4.4	49.5	383.0
BH100	337	Beech	West C.	327.0	81.7	76.4	.	.	.	1054.0
BH101	398	Pod/Brdlv/Bch	West C.	111.9	28.0	7.3	.	.	.	364.7
BH102	274	Other Shrub	West C.	90.1	22.5	101.9	0.4	4.4	0.1	308.7
BH103	301	Beech	West C.	218.3	54.6	27.8	.	.	.	741.6
BH104	278	Beech	West C.	150.0	37.5	5.0	.	.	.	481.4
BH105	390	Beech	West C.	260.8	65.2	65.8	.	.	.	794.7
BH106	396	Other Shrub	Tasman	0.0	0.0	7.4	.	.	.	0.0
BH107	324	Beech	Tasman	136.3	34.1	26.2	.	.	.	432.2
BH108	343	Beech	Tasman	130.0	32.5	27.3	.	.	.	461.1
BH110	295	Beech	Tasman	127.8	32.0	12.2	.	3.4	.	386.0
BH111	334	Beech	Tasman	183.8	45.9	22.5	.	.	.	643.5
BH112	351	Other Shrub	Tasman	70.4	17.6	37.8	.	.	.	245.4
BH114	350	Beech	West C.	298.8	74.7	17.6	.	.	.	1070.2
BH115	317	Beech	West C.	200.4	50.1	32.7	.	.	.	702.6
BH116	345	Beech	West C.	207.0	51.7	22.7	.	.	.	712.3
BH119	323	Beech	Canterbury	63.2	15.8	32.8	.	8.9	9.6	221.0
BH120	327	Beech	Canterbury	191.1	47.8	48.3	.	.	.	683.7
BH121	320	Beech	Canterbury	119.8	30.0	11.0	.	.	.	419.4
BH127	303	Beech	Canterbury	55.5	13.9	15.7	.	.	.	169.9
BH95	386	Pod/Brdlv/Bch	West C.	41.1	10.3	1.8	.	.	.	82.8
BH96	340	Pod/Brdlv/Bch	West C.	153.2	38.3	89.8	0.0	1.8	0.4	587.7
BH97	344	Other Shrub	West C.	7.1	1.8	0.0	.	.	.	12.6
BH99	298	Bch/Pod/Brdlf	West C.	127.0	31.8	17.1	.	.	.	369.0
BI100	322	Beech	West C.	105.7	26.4	4.6	.	.	.	254.6
BI101	338	Beech	West C.	89.6	22.4	4.0	0.2	10.0	6.9	251.7
BI104	309	Beech	Tasman	164.1	41.0	25.1	.	.	.	559.9
BI105	315	Beech	Tasman	177.2	44.3	16.6	.	.	.	602.5
BI106	384	Beech	Tasman	185.8	46.5	22.4	1.2	2.6	3.4	666.6
BI107	336	Beech	Tasman	96.1	24.0	20.0	.	.	.	322.7
BI109	349	Beech	Tasman	58.0	14.5	45.6	.	6.1	11.9	197.5
BI110	308	Beech	Tasman	156.8	39.2	50.2	.	.	.	577.7
BI111	344	Beech	Tasman	190.7	47.7	62.5	.	.	.	723.5
BI112	325	Beech	Tasman	198.7	49.7	18.4	.	.	.	722.8
BI114	290	Beech	Tasman	89.0	22.3	53.6	.	.	.	301.5
BI115	278	Beech	West C.	105.8	26.4	16.2	.	.	.	333.4
BI116	293	Beech	Canterbury	187.5	46.9	8.9	.	.	.	580.4
BI117	353	Beech	Canterbury	103.3	25.8	9.0	.	.	.	314.5
BI118	296	Beech	Canterbury	279.6	69.9	23.1	.	4.5	74.3	982.6
BI119	352	Beech	Canterbury	127.2	31.8	19.7	.	6.1	23.2	401.6
BI121	290	Other Shrub	Canterbury	8.3	2.1	0.8	.	.	.	17.1
BI123	288	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0
BI127	364	Beech	Canterbury	52.3	13.1	23.1	.	9.5	0.0	156.1
BI128	391	Other Shrub	Canterbury	0.0	0.0	0.0	.	2.0	0.0	0.0
BI131	392	Other Shrub	Canterbury	0.1	0.0	0.0	.	.	.	0.2

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BI94	318	Pod/Brdlv/Bch	Tasman	224.8	56.2	17.0	.	.	.	675.8
BI95	378	Bch/Pod/Brdlf	Tasman	72.5	18.1	2.2	.	.	.	214.8
BI96	329	Bch/Pod/Brdlf	West C.	129.3	32.3	30.4	.	.	.	449.6
BI97	389	Beech	West C.	289.3	72.3	31.3	.	.	.	1072.8
BI99	360	Beech	West C.	251.0	62.8	49.4	4.3	3.5	10.3	902.9
BJ100	354	Beech	West C.	107.8	27.0	6.1	0.7	4.6	0.3	294.7
BJ101	326	Beech	West C.	244.9	61.2	38.0	.	.	.	878.4
BJ102	292	Beech	West C.	228.3	57.1	39.0	.	.	.	735.7
BJ103	278	Beech	Tasman	129.6	32.4	9.6	1.6	5.1	78.7	330.3
BJ104	340	Beech	Tasman	237.0	59.2	39.3	.	5.6	31.4	831.7
BJ105	354	Beech	Tasman	131.5	32.9	19.5	0.1	4.2	19.3	383.3
BJ108	325	Beech	Tasman	180.2	45.1	24.5	.	.	.	670.5
BJ109	308	Beech	Tasman	153.7	38.4	14.2	.	.	.	465.7
BJ110	311	Beech	Tasman	153.2	38.3	48.9	.	2.6	18.3	544.8
BJ111	367	Beech	Tasman	131.9	33.0	20.5	.	.	.	415.5
BJ112	341	Beech	Tasman	175.8	43.9	18.9	.	.	.	604.1
BJ115	322	Beech	West C.	86.8	21.7	13.1	.	.	.	284.1
BJ120	314	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0
BJ121	310	Other Shrub	Canterbury	2.1	0.5	26.4	.	0.5	4.9	4.1
BJ124	323	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0
BJ93	357	Pod/Brdlv/Bch	Tasman	188.7	47.2	34.2	.	.	.	626.3
BJ94	341	Bch/Pod/Brdlf	Tasman	238.8	59.7	45.8	1.7	6.1	1.0	759.1
BJ95	317	Bch/Pod/Brdlf	Tasman	161.6	40.4	26.4	.	.	.	437.0
BJ96	355	Bch/Pod/Brdlf	Tasman	315.9	79.0	40.2	.	.	.	849.7
BJ97	316	Bch/Pod/Brdlf	Tasman	64.6	16.1	23.9	0.1	4.2	7.3	216.1
BJ98	333	Beech	West C.	200.1	50.0	28.5	.	.	.	714.5
BJ99	294	Beech	West C.	144.5	36.1	44.6	.	.	.	493.8
BK100	348	Bch/Pod/Brdlf	West C.	148.9	37.2	9.5	.	.	.	497.7
BK101	298	Bch/Pod/Brdlf	West C.	98.2	24.5	28.8	.	.	.	328.4
BK102	361	Beech	Tasman	114.2	28.6	6.0	.	.	.	323.5
BK103	389	Beech	Tasman	203.6	50.9	14.1	.	.	.	763.4
BK105	384	Beech	Tasman	135.8	33.9	35.0	.	.	.	491.5
BK106	326	Beech	Tasman	174.2	43.5	8.9	.	.	.	555.6
BK107	379	Beech	Tasman	133.8	33.4	25.1	.	.	.	468.4
BK108	288	Beech	Tasman	112.3	28.1	41.5	.	4.1	9.9	397.2
BK109	306	Beech	Tasman	169.0	42.3	47.3	.	.	.	604.7
BK110	367	Beech	Tasman	238.3	59.6	37.7	.	.	.	860.1
BK111	303	Beech	Tasman	130.4	32.6	20.7	.	.	.	442.5
BK112	275	Beech	Tasman	88.4	22.1	15.0	.	5.8	42.5	306.8
BK113	344	Beech	Tasman	0.0	0.0	0.0	.	.	.	0.0
BK115	338	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0
BK118	292	Beech	Canterbury	57.7	14.4	19.9	.	.	.	172.3
BK119	346	Unsp Indg	Canterbury	60.7	15.2	0.0	.	3.7	0.0	129.4
BK120	314	Beech	Canterbury	82.0	20.5	20.4	.	.	.	256.7
BK126	356	Beech	Canterbury	57.9	14.5	25.4	.	.	.	163.2
BK91	362	Other Shrub	Tasman	0.1	0.0	0.5	.	.	.	0.2
BK92	373	Pod/Brdlv/Bch	Tasman	94.8	23.7	21.0	.	.	.	323.6
BK93	236	Pod/Brdlv/Bch	Tasman	89.9	22.5	22.6	0.7	6.9	121.8	227.8
BK94	289	Other Shrub	Tasman	14.3	3.6	1.2	1.0	5.7	6.7	31.4
BK95	325	Bch/Pod/Brdlf	Tasman	84.1	21.0	5.0	.	.	.	207.6

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BK97	323	SubalpShrub	Tasman	6.7	1.7	0.0	.	.	.	14.2
BK98	396	Beech	Tasman	152.3	38.1	11.9	.	.	.	547.3
BK99	304	Beech	West C.	268.5	67.1	56.3	.	.	.	934.6
BL101	296	Beech	Tasman	162.8	40.7	6.6	0.9	5.3	291.6	406.7
BL102	354	Beech	Tasman	188.7	47.2	54.3	.	.	.	652.3
BL104	325	Bch/Pod/Brdlf	Tasman	106.3	26.6	27.2	.	.	.	305.9
BL105	376	Beech	Tasman	160.0	40.0	6.2	.	8.2	74.2	429.9
BL106	337	Bch/Pod/Brdlf	Tasman	132.9	33.2	14.2	.	.	.	472.1
BL107	398	Beech	Tasman	261.8	65.4	42.9	.	.	.	920.1
BL108	346	Beech	Tasman	227.7	56.9	18.3	.	.	.	807.3
BL109	388	Bch/Pod/Brdlf	Tasman	174.1	43.5	24.1	.	4.8	41.3	626.4
BL110	292	Beech	Tasman	189.0	47.2	9.3	.	.	.	612.2
BL115	342	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0
BL117	291	Unsp Indg	Canterbury	2.3	0.6	0.0	.	3.3	0.3	4.4
BL118	361	Beech	Canterbury	62.4	15.6	19.9	.	.	.	188.7
BL121	335	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0
BL125	385	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0
BL127	374	Other Shrub	Canterbury	32.8	8.2	0.1	.	.	.	66.0
BL90	394	Other Shrub	Tasman	20.3	5.1	2.8	.	.	.	62.8
BL94	302	Bch/Pod/Brdlf	Tasman	209.3	52.3	14.6	.	.	.	649.3
BL95	390	Beech	Tasman	158.0	39.5	7.5	1.3	6.1	10.4	537.2
BL96	351	Beech	Tasman	94.1	23.5	19.2	3.1	5.3	0.7	279.4
BL97	322	Beech	Tasman	143.2	35.8	18.1	.	.	.	452.1
BL98	359	Beech	Tasman	94.4	23.6	18.0	3.1	9.3	7.2	275.5
BL99	372	Beech	Tasman	98.4	24.6	1.7	.	.	.	236.1
BM100	356	Beech	Tasman	111.6	27.9	62.7	.	.	.	387.7
BM101	331	Other Shrub	Tasman	4.9	1.2	0.0	0.0	10.7	1.4	12.3
BM105	345	Bch/Pod/Brdlf	Tasman	131.6	32.9	9.4	.	.	.	405.1
BM106	361	Bch/Pod/Brdlf	Tasman	143.7	35.9	48.4	.	.	.	523.6
BM108	388	Beech	Tasman	160.0	40.0	16.7	.	.	.	577.9
BM115	344	Other Shrub	Canterbury	0.0	0.0	0.0	.	2.1	0.0	0.0
BM116	330	Other Shrub	Canterbury	0.0	0.0	0.0	.	0.7	0.0	0.0
BM117	331	Beech	Canterbury	89.4	22.3	3.5	.	.	.	253.9
BM90	396	Other Shrub	Tasman	0.0	0.0	0.0	.	.	.	0.0
BM95	300	Other Shrub	Tasman	29.7	7.4	0.4	.	.	.	88.0
BM96	310	Bch/Pod/Brdlf	Tasman	125.2	31.3	14.4	.	.	.	430.6
BM97	288	Other Shrub	Tasman	2.4	0.6	0.3	.	.	.	4.1
BM98	314	Other Shrub	Tasman	53.5	13.4	0.7	.	.	.	137.0
BM99	375	Bch/Pod/Brdlf	Tasman	143.8	36.0	22.2	0.4	5.0	5.6	492.7
BN107	324	Beech	Tasman	203.6	50.9	25.4	.	.	.	706.9
BN109	307	Beech	Marlbr.	141.9	35.5	14.2	.	.	.	437.5
BN115	330	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0
BN116	394	Other Shrub	Canterbury	0.0	0.0	0.0	.	0.2	0.0	0.0
BN126	362	Other Shrub	Canterbury	2.2	0.5	0.0	.	.	.	4.5
BN98	359	Beech	Tasman	107.6	26.9	20.9	.	.	.	346.1
BO105	300	Beech	Tasman	86.6	21.6	8.4	.	.	.	225.4
BO106	385	Beech	Tasman	160.2	40.0	5.9	.	7.0	2.4	521.9
BO108	314	Beech	Marlbr.	105.6	26.4	9.9	.	6.1	30.9	322.1
BO109	322	Beech	Marlbr.	120.3	30.1	14.9	.	.	.	382.6
BO110	334	Beech	Marlbr.	99.9	25.0	8.2	.	.	.	299.3

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BO116	355	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0
BO95	362	Pod/Brdlf	Tasman	175.6	43.9	40.3	.	.	.	560.5
BO96	395	Pod/Brdlv/Bch	Tasman	159.1	39.8	25.0	.	.	.	533.8
BO98	335	Other Shrub	Tasman	12.2	3.1	1.0	.	.	.	30.8
BP104	360	Beech	Tasman	119.5	29.9	26.2	.	.	.	408.3
BP105	355	Other Shrub	Tasman	20.4	5.1	5.7	.	.	.	40.3
BP108	329	Beech	Marlbr.	89.5	22.4	40.7	.	.	.	293.4
BP117	389	Beech	Canterbury	54.2	13.6	16.6	.	.	.	162.2
BP135	354	Planted	Canterbury	63.2	15.8	4.9	.	2.9	2.7	255.5
BP136	330	Other Shrub	Canterbury	90.4	22.6	6.0	.	3.4	1.4	289.8
BP95	379	Other Shrub	Tasman	31.1	7.8	2.0	.	.	.	79.4
BP96	329	Pod/Brdlf	Tasman	104.9	26.2	24.6	.	.	.	398.9
BQ104	351	Beech	Tasman	159.3	39.8	21.0	.	.	.	505.8
BQ105	326	Beech	Tasman	84.1	21.0	9.1	.	.	.	285.8
BQ106	334	Other Shrub	Marlbr.	25.2	6.3	0.0	0.0	1.9	2.0	49.5
BQ108	328	Beech	Marlbr.	68.6	17.1	30.6	.	.	.	232.8
BQ110	323	Other Shrub	Marlbr.	0.3	0.1	0.0	.	.	.	0.8
BQ116	338	Other Shrub	Marlbr.	0.0	0.0	0.0	.	.	.	0.0
BQ118	341	Other Shrub	Canterbury	74.3	18.6	0.5	.	.	.	174.6
BQ123	336	Planted	Canterbury	46.4	11.6	0.0	.	.	.	160.5
BQ16	346	Other Shrub	Northland	10.0	2.5	0.0	.	.	.	17.4
BR103	339	Beech	Tasman	190.2	47.5	18.7	0.9	7.6	80.8	642.3
BR104	333	Beech	Marlbr.	183.8	46.0	8.5	.	8.2	30.1	579.9
BR105	336	Beech	Marlbr.	74.2	18.5	0.0	.	.	.	201.2
BR108	339	Other Shrub	Marlbr.	3.3	0.8	0.0	.	.	.	5.9
BR116	290	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0
BR12	400	Other Shrub	Northland	0.0	0.0	0.0	.	.	.	0.0
BR14	376	Other Shrub	Northland	13.9	3.5	2.0	0.0	1.1	0.0	34.1
BR17	368	Broadleaf	Northland	48.0	12.0	0.1	0.0	1.1	0.0	155.6
BR18	358	Other Shrub	Northland	67.3	16.8	1.0	0.2	5.6	0.0	201.9
BS101	323	Other Shrub	Nelson	75.0	18.8	1.8	.	.	.	206.9
BS103	351	Bch/Pod/Brdlf	Marlbr.	229.3	57.3	10.0	.	.	.	745.0
BS104	352	Beech	Marlbr.	203.4	50.9	28.0	.	.	.	708.0
BS105	286	Beech	Marlbr.	47.2	11.8	0.4	.	.	.	126.1
BS107	301	Beech	Marlbr.	86.5	21.6	4.9	.	.	.	272.8
BS114	319	Other Shrub	Marlbr.	0.0	0.0	0.0	.	.	.	0.0
BS115	339	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0
BS12	405	Other Shrub	Northland	2.8	0.7	0.0	0.0	.	.	5.0
BS16	373	Pod/Brdlf	Northland	119.8	29.9	9.6	.	.	.	378.1
BS17	396	Other Shrub	Northland	53.5	13.4	0.1	.	.	.	131.3
BT101	331	Bch/Brdlv	Nelson	89.5	22.4	32.3	.	.	.	283.4
BT102	384	Pod/Brdlv/Bch	Marlbr.	197.0	49.3	10.9	0.4	5.7	3.0	626.9
BT104	343	Beech	Marlbr.	135.3	33.8	7.7	.	.	.	492.5
BT108	337	Other Shrub	Marlbr.	0.5	0.1	0.1	.	0.3	0.0	0.9
BT114	386	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.0
BT115	276	Other Shrub	Canterbury	0.0	0.0	0.0	.	5.7	2.5	0.0
BT119	380	Other Shrub	Canterbury	2.4	0.6	0.7	.	.	.	7.9
BT13	400	Other Shrub	Northland	0.0	0.0	0.0	0.0	1.8	0.0	0.0
BT19	381	Other Shrub	Northland	51.4	12.9	2.2	.	.	.	142.0
BU100	369	Bch/Pod/Brdlf	Marlbr.	171.8	42.9	9.9	.	.	.	507.4

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BU101	351	Pod/Brdlv/Bch	Marlbr.	212.5	53.1	8.7	0.0	5.7	4.3	705.8
BU102	339	Pod/Brdlv/Bch	Marlbr.	212.1	53.0	3.8	.	.	.	725.3
BU103	367	Bch/Pod/Brdlf	Marlbr.	221.7	55.4	42.0	.	.	.	774.6
BU108	338	Beech	Marlbr.	125.4	31.4	16.3	.	.	.	461.4
BU109	303	Other Shrub	Marlbr.	0.0	0.0	0.0	.	.	.	0.0
BU115	325	Other Shrub	Canterbury	0.0	0.0	0.0	.	.	.	0.1
BU117	319	Other Shrub	Canterbury	113.3	28.3	1.8	.	3.3	0.0	366.3
BU14	389	Planted	Northland	0.0	0.0	2.6	6.1	11.8	4.0	0.0
BU16	372	Pod/Brdlf	Northland	88.5	22.1	8.0	.	.	.	303.4
BU18	358	Other Shrub	Northland	23.5	5.9	0.8	.	.	.	83.3
BU22	353	Unsp Indg	Northland	44.5	11.1	9.7	0.2	3.2	0.9	148.1
BU99	360	Bch/Brdlv	Nelson	42.8	10.7	0.6	.	.	.	104.1
BV103	359	Bch/Pod/Brdlf	Marlbr.	197.6	49.4	20.4	.	.	.	673.6
BV13	371	Other Shrub	Northland	22.4	5.6	0.0	0.1	2.8	0.0	48.4
BV14	388	Other Shrub	Northland	16.8	4.2	0.0	.	.	.	45.6
BV15	356	Other Shrub	Northland	106.9	26.7	4.4	.	.	.	337.3
BV19	379	Unsp Indg	Northland	58.1	14.5	6.9	.	.	.	182.9
BV22	393	Pod/Brdlf	Northland	69.7	17.4	7.0	.	.	.	229.5
BV23	399	Pod/Brdlf	Northland	36.1	9.0	6.9	.	.	.	117.6
BV98	320	Bch/Pod/Brdlf	Nelson	117.4	29.4	2.2	.	.	.	335.4
BV99	389	Bch/Pod/Brdlf	Marlbr.	82.7	20.7	8.5	.	.	.	321.4
BW100	303	Bch/Pod/Brdlf	Marlbr.	610.7	152.7	24.8	4.0	7.8	4.5	1950.9
BW101	346	Other Shrub	Marlbr.	18.4	4.6	8.6	.	.	.	99.2
BW102	348	Bch/Pod/Brdlf	Marlbr.	222.5	55.6	40.2	.	.	.	717.9
BW107	333	Other Shrub	Marlbr.	86.5	21.6	0.9	.	.	.	208.9
BW111	329	Other Shrub	Canterbury	2.3	0.6	0.0	.	3.5	4.7	4.1
BW115	395	Other Shrub	Canterbury	26.1	6.5	0.1	.	.	.	66.7
BW13	393	Pod/Brdlf	Northland	26.9	6.7	0.3	.	.	.	114.1
BW16	390	Planted	Northland	28.6	7.1	0.2	0.4	5.8	5.9	126.4
BW17	384	Pod/Brdlf	Northland	114.0	28.5	6.8	.	.	.	386.6
BW20	399	Other Shrub	Northland	2.4	0.6	0.0	.	.	.	6.4
BW21	385	Pod/Brdlf	Northland	178.4	44.6	23.7	.	.	.	592.9
BW22	390	Pod/Brdlf	Northland	281.3	70.3	29.4	0.9	4.2	35.8	878.9
BW98	374	Bch/Brdlv	Marlbr.	147.2	36.8	3.5	1.0	5.3	13.1	460.9
BW99	315	Bch/Pod/Brdlf	Marlbr.	194.5	48.6	9.1	.	.	.	598.4
BX100	331	Bch/Pod/Brdlf	Marlbr.	108.3	27.1	3.9	0.0	5.4	0.6	410.3
BX107	329	Other Shrub	Marlbr.	0.0	0.0	0.0	.	.	.	0.0
BX108	351	Other Shrub	Marlbr.	0.0	0.0	10.0	.	3.7	0.0	0.0
BX110	345	Unsp Indg	Canterbury	93.0	23.2	1.3	.	.	.	225.5
BX111	322	Other Shrub	Canterbury	23.7	5.9	0.0	.	.	.	46.9
BX112	359	Other Shrub	Canterbury	159.6	39.9	7.7	.	.	.	536.5
BX114	309	Unsp Indg	Canterbury	160.0	40.0	1.1	.	.	.	563.3
BX15	388	Unsp Indg	Northland	25.8	6.4	0.5	0.3	7.7	4.6	156.7
BX17	370	Pod/Brdlf	Northland	156.5	39.1	3.1	.	.	.	569.9
BX21	353	Unsp Indg	Northland	13.9	3.5	4.4	.	.	.	65.7
BX24	327	Pod/Brdlf	Northland	86.0	21.5	5.0	0.0	4.1	8.7	417.1
BX97	340	Bch/Brdlv	Marlbr.	42.7	10.7	3.3	.	.	.	123.0
BY102	328	Other Shrub	Marlbr.	59.2	14.8	9.8	.	.	.	178.4
BY105	354	Other Shrub	Marlbr.	3.3	0.8	0.0	.	.	.	7.2
BY106	352	Other Shrub	Marlbr.	12.3	3.1	0.0	.	.	.	25.3

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BY109	347	Other Shrub	Marlbr.	44.0	11.0	0.6	.	.	.	95.8
BY111	327	Other Shrub	Canterbury	0.0	0.0	1.8	.	0.4	0.0	0.0
BY112	310	Other Shrub	Canterbury	5.5	1.4	0.0	.	.	.	11.4
BY16	323	Pod/Brdlf	Northland	48.4	12.1	1.9	.	.	.	148.5
BY94	319	Bch/Pod/Brdlf	Marlbr.	117.0	29.3	8.8	.	.	.	353.0
BY99	330	Planted	Marlbr.	75.3	18.8	0.0	1.4	11.7	1.1	261.9
BZ20	389	Unsp Indg	Northland	47.9	12.0	2.5	.	.	.	191.3
BZ21	364	Pod/Brdlf	Northland	102.1	25.5	14.5	0.0	2.4	0.3	315.8
BZ73	390	Pod/Brdlf	Taranaki	17.1	4.3	35.1	.	.	.	76.4
BZ98	340	Other Shrub	Marlbr.	0.0	0.0	0.0	.	.	.	0.0
BZ99	378	Planted	Marlbr.	38.6	9.6	18.9	.	.	.	135.9
CA101	347	Bch/Pod/Brdlf	Marlbr.	243.1	60.8	17.7	.	.	.	686.0
CA109	371	Other Shrub	Marlbr.	0.0	0.0	0.0	.	2.5	2.3	0.0
CA22	366	Other Shrub	Northland	0.9	0.2	0.3	.	.	.	2.0
CA72	281	Pod/Brdlf	Taranaki	177.5	44.4	13.7	.	.	.	460.7
CA74	384	Pod/Brdlf	Taranaki	165.4	41.4	95.3	0.0	.	.	601.7
CA98	370	Beech	Marlbr.	70.7	17.7	5.8	.	.	.	298.0
CA99	323	Bch/Pod/Brdlf	Marlbr.	141.1	35.3	24.5	.	.	.	417.6
CB16	360	Other Shrub	Northland	34.5	8.6	0.0	.	.	.	76.3
CB18	355	Pod/Brdlf	Northland	77.3	19.3	3.2	.	.	.	238.9
CB19	353	Unsp Indg	Northland	27.5	6.9	5.8	3.3	5.6	4.4	110.2
CB24	396	Other Shrub	Northland	12.4	3.1	0.1	1.0	5.2	12.7	30.9
CB31	394	Planted	Northland	73.1	18.3	0.0	1.5	3.4	1.3	258.9
CB73	381	Pod/Brdlf	Taranaki	239.2	59.8	17.8	0.1	2.2	9.1	732.5
CB74	388	Pod/Brdlf	Taranaki	73.7	18.4	38.5	.	.	.	206.1
CB98	320	Other Shrub	Marlbr.	2.7	0.7	0.0	.	.	.	4.9
CB99	366	Other Shrub	Marlbr.	78.9	19.7	0.7	6.8	3.7	0.0	200.4
CC18	338	Other Shrub	Northland	93.6	23.4	1.2	.	.	.	347.9
CC34	387	Other Shrub	Auckland	0.0	0.0	0.0	.	.	.	0.0
CD17	363	Other Shrub	Northland	41.9	10.5	0.0	0.9	3.4	0.2	96.1
CD18	345	Pod/Brdlf	Northland	73.8	18.5	12.1	1.6	6.6	0.0	290.3
CD19	370	Pod/Brdlf	Northland	61.4	15.4	80.7	.	.	.	259.4
CD26	373	Other Shrub	Northland	48.2	12.0	0.1	.	.	.	151.1
CE19	337	Other Shrub	Northland	53.8	13.5	0.5	.	.	.	154.1
CE20	313	Pod/Brdlf	Northland	67.2	16.8	2.7	.	.	.	247.1
CE21	364	Other Shrub	Northland	7.8	1.9	0.5	.	.	.	41.5
CE27	374	Pod/Brdlf	Northland	9.5	2.4	0.0	1.7	.	.	29.3
CE78	302	Broadleaf	Taranaki	5.2	1.3	7.0	1.3	2.5	3.0	15.9
CF21	338	Pod/Brdlf	Northland	62.5	15.6	0.0	.	.	.	188.6
CF23	330	Other Shrub	Northland	302.5	75.6	8.0	.	.	.	1130.6
CF40	375	Other Shrub	Auckland	11.9	3.0	0.4	.	.	.	27.2
CF69	375	Bch/Pod/Brdlf	Taranaki	14.0	3.5	0.7	.	.	.	53.0
CF70	291	Other Shrub	Taranaki	98.4	24.6	1.8	0.6	4.1	1.1	311.5
CF71	337	Other Shrub	Taranaki	0.0	0.0	0.0	.	.	.	0.0
CF72	369	Pod/Brdlf	Taranaki	52.1	13.0	44.3	.	.	.	266.6
CF77	305	Pod/Brdlf	Taranaki	54.8	13.7	14.7	.	.	.	226.3
CG22	372	Other Shrub	Northland	60.7	15.2	1.9	.	.	.	220.3
CG40	400	Kauri	Auckland	32.3	8.1	6.0	.	.	.	123.7
CG41	310	Kauri	Auckland	177.2	44.3	6.9	.	.	.	616.3
CG67	324	Pod/Brdlv/Bch	Taranaki	31.7	7.9	2.3	1.2	5.3	2.9	144.8

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CG68	361	Pod/Brdlv/Bch	Taranaki	60.9	15.2	9.3	.	.	.	296.0
CG69	235	Pod/Brdlv/Bch	Taranaki	130.4	32.6	3.7	.	.	.	402.7
CG70	301	Pod/Brdlf	Taranaki	131.9	33.0	19.6	.	.	.	416.1
CG76	355	Pod/Brdlv/Bch	Taranaki	111.9	28.0	4.5	.	.	.	475.6
CH35	314	Other Shrub	Auckland	40.3	10.1	2.1	.	.	.	172.7
CH41	389	Other Shrub	Auckland	78.6	19.6	3.3	0.0	2.7	1.7	271.2
CH44	395	Other Shrub	Waikato	11.1	2.8	0.0	0.0	.	.	47.3
CH64	313	Other Shrub	Waikato	17.0	4.2	1.2	.	.	.	152.4
CH66	299	Bch/Brdlv	Taranaki	86.6	21.6	8.2	.	.	.	376.3
CH67	317	Broadleaf	Taranaki	7.5	1.9	6.8	.	.	.	36.6
CH68	303	Pod/Brdlf	Taranaki	72.5	18.1	35.4	.	.	.	283.2
CH69	336	Pod/Brdlf	Taranaki	81.0	20.3	9.1	.	.	.	388.7
CH70	270	Other Shrub	Taranaki	21.0	5.3	2.9	.	.	.	173.4
CH72	325	Pod/Brdlv/Bch	Taranaki	93.0	23.2	5.2	0.1	5.5	12.1	318.9
CH75	296	Pod/Brdlv/Bch	Taranaki	224.3	56.1	4.0	0.3	9.1	31.6	693.3
CH76	318	Pod/Brdlv/Bch	Taranaki	206.8	51.7	25.0	.	.	.	730.0
CH78	343	Pod/Brdlv/Bch	Taranaki	86.8	21.7	42.0	.	.	.	286.0
CH79	307	Other Shrub	Taranaki	20.6	5.2	2.0	.	.	.	267.5
CI27	335	Unsp Indg	Northland	60.4	15.1	2.5	.	.	.	162.1
CI47	352	Other Shrub	Waikato	64.7	16.2	2.8	0.0	7.0	4.9	297.8
CI57	301	Other Shrub	Waikato	73.9	18.5	13.6	.	.	.	260.1
CI59	350	Pod/Brdlf	Waikato	112.4	28.1	40.7	.	.	.	445.9
CI60	274	Pod/Brdlf	Waikato	66.9	16.7	2.6	.	.	.	277.9
CI61	341	Pod/Brdlf	Waikato	142.0	35.5	4.9	.	.	.	559.4
CI62	322	Pod/Brdlf	Waikato	134.3	33.6	50.5	.	.	.	492.5
CI65	285	Other Shrub	Waikato	6.5	1.6	0.0	.	.	.	12.8
CI67	337	Pod/Brdlf	Taranaki	180.6	45.1	10.4	.	.	.	621.9
CI71	342	Other Shrub	Taranaki	59.3	14.8	22.4	1.5	5.2	12.4	214.7
CI72	312	Pod/Brdlv/Bch	Taranaki	80.8	20.2	5.4	.	.	.	303.9
CI73	307	Pod/Brdlv/Bch	Taranaki	89.7	22.4	2.3	.	.	.	298.3
CI74	292	Pod/Brdlv/Bch	Taranaki	70.0	17.5	40.6	7.3	.	.	232.7
CI75	308	Pod/Brdlf	Taranaki	203.8	50.9	11.0	.	.	.	648.8
CI76	330	Pod/Brdlv/Bch	Taranaki	78.7	19.7	13.3	.	.	.	266.7
CI78	271	Pod/Brdlv/Bch	Taranaki	190.3	47.6	6.3	0.6	.	.	634.5
CI79	327	Pod/Brdlv/Bch	Taranaki	164.6	41.2	28.6	0.4	6.4	6.9	527.5
CJ101	303	Beech	Wellington	74.8	18.7	24.0	1.1	7.4	0.8	248.2
CJ102	300	Other Shrub	Wellington	36.4	9.1	8.8	.	.	.	123.2
CJ32	359	Other Shrub	Auckland	1.0	0.3	0.1	.	.	.	1.9
CJ44	385	Other Shrub	Waikato	2.3	0.6	0.0	.	.	.	5.5
CJ59	334	Pod/Brdlf	Waikato	29.0	7.3	3.3	.	.	.	173.5
CJ60	335	Pod/Brdlf	Waikato	86.8	21.7	3.2	.	.	.	270.8
CJ64	279	Broadleaf	Waikato	81.8	20.5	16.6	.	.	.	323.7
CJ65	354	Bch/Pod/Brdlf	Waikato	59.4	14.8	34.2	.	.	.	308.0
CJ66	294	Pod/Brdlv/Bch	Waikato	189.5	47.4	7.2	0.2	3.2	59.5	606.4
CJ67	312	Broadleaf	Man/Wan	185.3	46.3	9.6	.	.	.	634.8
CJ68	312	Pod/Brdlv/Bch	Taranaki	219.3	54.8	16.9	.	.	.	752.1
CJ71	317	Other Shrub	Taranaki	41.1	10.3	0.1	.	.	.	224.8
CJ72	318	Pod/Brdlf	Taranaki	200.9	50.2	4.5	.	.	.	596.2
CJ73	312	Pod/Brdlv/Bch	Man/Wan	101.7	25.4	2.9	0.0	2.8	34.4	399.4
CJ74	330	Pod/Brdlf	Man/Wan	172.2	43.1	34.0	.	.	.	580.1

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CJ75	303	Pod/Brdlf	Taranaki	197.4	49.3	18.6	.	.	.	693.9
CJ79	309	Pod/Brdlv/Bch	Taranaki	191.4	47.8	15.2	.	.	.	598.4
CJ95	359	Other Shrub	Wellington	119.9	30.0	5.2	.	.	.	351.6
CK101	383	Bch/Pod/Brdlf	Wellington	89.4	22.4	6.1	.	.	.	262.8
CK36	366	Other Shrub	Auckland	0.2	0.1	0.0	0.1	3.6	6.3	0.6
CK48	329	Pod/Brdlf	Waikato	74.2	18.5	0.6	.	.	.	337.7
CK55	371	Other Shrub	Waikato	139.4	34.9	24.4	.	.	.	504.8
CK59	372	Pod/Brdlf	Waikato	176.8	44.2	20.2	2.6	4.4	162.8	630.1
CK60	378	Pod/Brdlf	Waikato	150.8	37.7	8.0	1.0	.	.	552.0
CK63	381	Other Shrub	Waikato	19.7	4.9	0.3	.	.	.	55.3
CK72	285	Pod/Brdlv/Bch	Man/Wan	27.9	7.0	8.3	.	.	.	149.9
CK73	319	Other Shrub	Man/Wan	26.0	6.5	1.2	.	.	.	89.7
CK74	314	Other Shrub	Man/Wan	34.5	8.6	0.0	1.3	6.6	5.6	84.4
CK75	360	Pod/Brdlv/Bch	Man/Wan	89.0	22.3	1.5	0.0	6.7	4.2	321.5
CK81	389	Other Shrub	Man/Wan	1.4	0.3	0.0	.	.	.	3.6
CK97	352	Pod/Brdlf	Wellington	202.2	50.5	34.6	.	.	.	595.9
CK98	325	Other Shrub	Wellington	21.3	5.3	0.0	.	.	.	70.7
CL100	390	Bch/Pod/Brdlf	Wellington	273.7	68.4	21.5	0.7	4.5	7.4	884.4
CL43	351	Pod/Brdlf	Auckland	77.8	19.5	4.7	.	.	.	279.3
CL55	327	Pod/Brdlf	Waikato	108.4	27.1	15.8	.	.	.	388.7
CL57	340	Pod/Brdlf	Waikato	58.7	14.7	7.8	0.3	5.3	41.2	237.0
CL58	309	Pod/Brdlf	Waikato	128.4	32.1	58.6	.	.	.	426.1
CL71	291	Pod/Brdlv/Bch	Man/Wan	45.1	11.3	9.3	.	.	.	164.4
CL72	303	Pod/Brdlf	Man/Wan	85.1	21.3	7.7	.	.	.	266.7
CL73	342	Other Shrub	Man/Wan	3.6	0.9	0.7	.	.	.	7.9
CL74	319	Pod/Brdlv/Bch	Man/Wan	96.3	24.1	29.3	.	.	.	297.1
CL75	294	Planted	Man/Wan	40.9	10.2	17.7	.	.	.	142.5
CL76	341	Pod/Brdlv/Bch	Man/Wan	134.6	33.7	6.9	.	.	.	436.2
CL78	335	Pod/Brdlv/Bch	Man/Wan	148.6	37.2	14.7	.	.	.	459.2
CL79	303	Pod/Brdlv/Bch	Man/Wan	189.4	47.4	4.4	.	.	.	612.4
CL80	289	Other Shrub	Man/Wan	72.9	18.2	1.3	0.3	2.1	0.7	277.7
CL96	306	Beech	Wellington	254.1	63.5	39.8	.	.	.	858.0
CL97	331	Pod/Brdlf	Wellington	17.3	4.3	3.2	.	.	.	65.2
CL99	399	Other Shrub	Wellington	0.0	0.0	0.0	.	.	.	0.0
CM104	305	Bch/Brdlv	Wellington	89.9	22.5	8.0	.	.	.	253.3
CM39	384	Unsp Indg	Auckland	31.7	7.9	0.5	.	.	.	109.3
CM51	295	Other Shrub	Waikato	135.2	33.8	27.3	.	.	.	469.4
CM55	326	Pod/Brdlf	Waikato	134.6	33.6	11.3	.	.	.	605.0
CM56	314	Pod/Brdlf	Waikato	78.3	19.6	52.1	.	.	.	338.5
CM64	317	Beech	Waikato	70.3	17.6	10.4	.	.	.	291.9
CM70	290	Broadleaf	Man/Wan	19.6	4.9	0.1	.	.	.	186.5
CM74	370	Other Shrub	Man/Wan	9.0	2.3	1.2	.	.	.	49.8
CM76	331	Broadleaf	Man/Wan	161.8	40.4	38.3	0.0	1.7	0.0	540.5
CM79	326	Pod/Brdlv/Bch	Man/Wan	59.0	14.8	7.9	.	.	.	294.4
CM95	325	Broadleaf	Wellington	145.1	36.3	16.1	1.0	5.3	0.9	414.9
CM96	326	Bch/Pod/Brdlf	Wellington	292.2	73.0	20.8	.	.	.	933.1
CM97	289	Bch/Pod/Brdlf	Wellington	151.4	37.9	12.5	.	.	.	456.0
CM98	393	Other Shrub	Wellington	25.1	6.3	0.0	.	.	.	73.8
CM99	333	Pod/Brdlv/Bch	Wellington	71.7	17.9	0.9	.	.	.	170.6
CN102	336	Bch/Brdlv	Wellington	61.5	15.4	6.3	0.2	6.0	0.1	172.6

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CN103	328	Bch/Pod/Brdlf	Wellington	193.7	48.4	5.3	.	.	.	683.9
CN104	340	Bch/Brdlv	Wellington	26.5	6.6	8.8	.	.	.	98.9
CN105	370	Bch/Pod/Brdlf	Wellington	127.9	32.0	1.2	1.4	6.6	0.3	389.7
CN40	392	Other Shrub	Auckland	28.4	7.1	1.9	0.2	1.7	2.0	65.6
CN42	373	Pod/Brdlf	Waikato	42.7	10.7	11.9	.	.	.	215.7
CN43	320	Pod/Brdlf	Waikato	92.5	23.1	12.4	.	.	.	346.5
CN72	311	Broadleaf	Man/Wan	64.7	16.2	17.1	0.6	.	.	259.9
CN73	310	Other Shrub	Man/Wan	29.6	7.4	0.7	.	.	.	80.1
CN78	297	Pod/Brdlv/Bch	Man/Wan	134.7	33.7	37.3	2.0	5.7	1.8	421.3
CN93	371	Other Shrub	Man/Wan	13.2	3.3	10.2	.	.	.	39.0
CN94	375	Bch/Pod/Brdlf	Wellington	156.7	39.2	42.9	1.3	8.2	14.1	507.1
CN95	362	Bch/Pod/Brdlf	Wellington	196.5	49.1	31.7	3.1	.	.	690.4
CN96	310	SubalpShrub	Wellington	12.9	3.2	6.5	.	.	.	33.2
CN97	364	Bch/Pod/Brdlf	Wellington	266.6	66.6	13.6	.	.	.	821.9
CN98	318	Pod/Brdlv/Bch	Wellington	163.6	40.9	18.8	.	.	.	494.2
CO103	326	Planted	Wellington	37.5	9.4	2.5	0.6	2.4	0.6	99.7
CO42	367	Pod/Brdlf	Waikato	47.9	12.0	0.6	.	.	.	237.9
CO63	380	Unsp Indg	Waikato	0.0	0.0	0.0	.	.	.	0.0
CO65	375	Pod/Brdlf	Man/Wan	56.5	14.1	5.3	.	.	.	319.9
CO72	394	Broadleaf	Man/Wan	21.5	5.4	13.4	.	.	.	64.4
CO73	382	Broadleaf	Man/Wan	81.7	20.4	36.9	.	.	.	289.6
CO93	325	Pod/Brdlf	Man/Wan	85.0	21.3	31.1	.	.	.	393.4
CO94	278	Beech	Wellington	120.0	30.0	2.1	0.7	3.0	0.1	359.8
CO95	329	Beech	Wellington	210.1	52.5	32.9	.	.	.	709.8
CO96	226	Bch/Pod/Brdlf	Wellington	86.0	21.5	30.5	4.9	3.6	0.6	244.1
CO97	293	Pod/Brdlv/Bch	Wellington	235.2	58.8	18.0	1.2	9.7	35.0	700.9
CP35	358	Pod/Brdlf	Waikato	54.6	13.7	3.4	.	.	.	206.5
CP61	344	Pod/Brdlf	Waikato	200.7	50.2	25.6	0.3	3.0	0.2	758.4
CP63	356	Pod/Brdlf	Waikato	254.8	63.7	0.9	0.8	.	.	905.0
CP65	392	Broadleaf	Man/Wan	81.2	20.3	24.3	.	.	.	467.7
CP70	385	Pod/Brdlf	Man/Wan	81.3	20.3	21.2	0.0	4.4	5.2	284.0
CP73	369	Bch/Pod/Brdlf	Man/Wan	105.7	26.4	18.8	0.2	3.4	19.4	351.2
CP74	379	Beech	Man/Wan	114.3	28.6	14.7	1.1	3.0	26.4	358.2
CP91	311	Other Shrub	Man/Wan	51.6	12.9	9.5	0.4	2.8	0.0	138.3
CP92	321	Pod/Brdlf	Man/Wan	119.0	29.8	6.3	0.6	6.0	26.2	379.2
CP93	335	SubalpShrub	Wellington	3.5	0.9	0.0	0.0	4.6	37.5	6.9
CP94	275	Beech	Wellington	176.8	44.2	52.4	.	.	.	743.1
CP95	307	Beech	Wellington	231.2	57.8	12.4	.	.	.	751.1
CQ102	392	Other Shrub	Wellington	40.2	10.1	0.5	.	.	.	98.7
CQ30	398	Other Shrub	Auckland	13.4	3.3	0.1	.	.	.	28.9
CQ31	356	Other Shrub	Auckland	61.6	15.4	2.9	0.5	3.7	0.1	158.6
CQ35	348	Other Shrub	Waikato	72.0	18.0	23.2	.	.	.	209.9
CQ60	336	Pod/Brdlf	Waikato	90.0	22.5	21.4	.	.	.	323.1
CQ61	335	Pod/Brdlf	Waikato	49.7	12.4	3.3	0.0	3.2	0.1	209.4
CQ64	391	Planted	Man/Wan	0.0	0.0	47.9	34.9	22.9	2.9	0.0
CQ65	384	Pod/Brdlf	Man/Wan	110.6	27.6	19.4	.	.	.	328.7
CQ66	375	Pod/Brdlf	Man/Wan	121.1	30.3	34.6	.	.	.	348.1
CQ68	332	Other Shrub	Man/Wan	18.1	4.5	1.1	0.2	3.7	12.4	261.7
CQ69	326	Pod/Brdlf	Man/Wan	209.9	52.5	17.2	0.0	6.5	23.2	755.0
CQ70	385	Planted	Man/Wan	144.8	36.2	75.0	.	.	.	543.1

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CQ72	391	Beech	Man/Wan	93.2	23.3	12.2	.	.	.	302.6
CQ75	379	Beech	Man/Wan	161.5	40.4	26.4	.	.	.	490.3
CQ91	352	SubalpShrub	Man/Wan	0.0	0.0	0.5	.	.	.	0.0
CQ93	324	Pod/Brdlf	Man/Wan	178.9	44.7	16.6	.	.	.	551.7
CQ94	387	Other Shrub	Wellington	22.2	5.6	0.3	.	.	.	44.3
CR100	270	Other Shrub	Wellington	27.1	6.8	0.5	.	.	.	76.5
CR102	330	Other Shrub	Wellington	13.3	3.3	0.0	0.0	.	.	28.0
CR32	331	Other Shrub	Auckland	90.6	22.7	2.1	2.3	4.0	0.0	244.8
CR37	360	Unsp Indg	Waikato	26.8	6.7	0.4	.	.	.	67.5
CR38	341	Kauri	Waikato	59.8	14.9	15.5	.	.	.	233.7
CR40	394	Kauri	Waikato	101.2	25.3	55.3	.	.	.	411.6
CR41	354	Kauri	Waikato	15.5	3.9	0.1	.	.	.	32.6
CR42	305	Kauri	Waikato	35.9	9.0	3.7	1.2	3.0	0.3	144.7
CR43	318	Kauri	Waikato	63.2	15.8	7.0	0.0	4.3	0.7	229.4
CR56	279	Pod/Brdlf	Waikato	76.4	19.1	21.3	.	.	.	340.5
CR61	341	Pod/Brdlf	Waikato	122.1	30.5	0.3	.	.	.	407.7
CR62	382	Pod/Brdlf	Waikato	246.7	61.7	12.2	.	.	.	1040.1
CR64	395	Pod/Brdlf	Man/Wan	79.9	20.0	31.0	.	.	.	239.2
CR65	316	Pod/Brdlf	Waikato	145.9	36.5	40.9	.	.	.	489.9
CR66	376	Pod/Brdlf	Waikato	127.1	31.8	20.1	.	.	.	393.3
CR67	383	Pod/Brdlf	Waikato	157.5	39.4	17.0	0.8	2.3	6.4	482.2
CR90	321	Other Shrub	Man/Wan	14.2	3.6	20.2	.	.	.	93.8
CS100	379	Pod/Brdlv/Bch	Wellington	27.6	6.9	0.7	.	.	.	73.7
CS41	335	Kauri	Waikato	69.3	17.3	6.8	.	.	.	234.8
CS42	299	Kauri	Waikato	171.5	42.9	3.0	0.7	6.5	1.2	525.3
CS44	375	Other Shrub	Waikato	230.1	57.5	25.1	0.3	.	.	883.1
CS59	386	Unsp Indg	Waikato	2.7	0.7	0.1	0.1	0.6	0.0	24.2
CS61	346	Other Shrub	Waikato	10.5	2.6	0.0	.	.	.	24.6
CS63	369	Pod/Brdlf	Waikato	152.4	38.1	6.6	.	.	.	509.1
CS64	371	Broadleaf	Waikato	104.7	26.2	11.5	.	.	.	379.9
CS66	382	Other Shrub	Waikato	30.5	7.6	4.6	0.3	3.2	0.3	80.1
CS69	381	Pod/Brdlf	Waikato	50.2	12.6	2.8	.	.	.	124.8
CS71	363	Unsp Indg	Waikato	46.3	11.6	0.0	.	.	.	100.5
CS72	364	Beech	Waikato	249.6	62.4	7.4	0.5	6.0	11.0	911.6
CS77	384	Pod/Brdlf	Man/Wan	5.3	1.3	44.0	1.3	4.2	0.8	13.8
CS93	363	Other Shrub	Man/Wan	0.0	0.0	0.7	.	.	.	0.0
CT100	390	Other Shrub	Wellington	44.1	11.0	5.4	.	.	.	124.3
CT39	300	Other Shrub	Waikato	60.5	15.1	0.8	.	.	.	143.0
CT43	265	Kauri	Waikato	170.2	42.6	1.5	.	.	.	526.7
CT44	358	Kauri	Waikato	80.7	20.2	21.6	.	.	.	296.9
CT45	322	Kauri	Waikato	90.4	22.6	8.0	.	.	.	348.0
CT46	367	Kauri	Waikato	99.4	24.9	0.1	.	.	.	350.4
CT47	387	Pod/Brdlf	Waikato	109.4	27.4	1.6	0.0	4.1	32.9	383.3
CT48	332	Kauri	Waikato	84.1	21.0	18.0	.	.	.	283.5
CT49	336	Kauri	Waikato	130.2	32.5	1.7	.	.	.	439.4
CT65	390	Unsp Indg	Waikato	101.8	25.4	0.3	2.5	4.3	0.2	295.8
CT70	353	Pod/Brdlf	Waikato	72.0	18.0	3.1	.	.	.	292.8
CT72	362	Beech	Waikato	535.6	133.9	17.0	.	.	.	1969.9
CT73	322	Beech	Waikato	125.8	31.5	19.6	.	.	.	397.8
CT74	376	Beech	Man/Wan	107.4	26.9	14.2	.	.	.	331.6

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CT86	338	Other Shrub	Man/Wan	34.5	8.6	0.4	.	.	.	105.3
CT87	298	Other Shrub	Man/Wan	53.0	13.3	4.1	.	.	.	291.8
CT96	360	Other Shrub	Wellington	0.2	0.0	0.0	0.0	.	.	0.3
CU42	291	Other Shrub	Waikato	31.9	8.0	0.1	0.0	5.1	2.5	85.5
CU45	308	Broadleaf	Waikato	54.6	13.7	0.8	.	.	.	186.9
CU46	361	Kauri	Waikato	52.2	13.0	58.2	.	.	.	324.8
CU48	387	Broadleaf	Waikato	15.7	3.9	0.1	0.0	0.3	0.0	58.4
CU49	374	Pod/Brdlv/Bch	B.O.P.	62.5	15.6	69.3	.	.	.	267.7
CU50	380	Pod/Brdlf	Waikato	40.7	10.2	6.1	0.2	2.6	0.4	128.3
CU51	323	Pod/Brdlv/Bch	Waikato	135.9	34.0	18.7	1.1	.	.	465.7
CU65	375	Unsp Indg	Waikato	35.6	8.9	0.0	.	.	.	92.4
CU71	363	Beech	Waikato	178.2	44.6	77.9	1.5	3.4	8.6	635.0
CU72	329	Beech	Waikato	54.4	13.6	18.0	0.7	5.1	5.4	156.7
CU85	378	Unsp Indg	Man/Wan	207.8	52.0	34.6	.	.	.	622.6
CU86	330	Other Shrub	Man/Wan	34.3	8.6	17.8	.	.	.	73.5
CV46	383	Broadleaf	Waikato	51.4	12.9	0.2	.	.	.	135.5
CV52	380	Broadleaf	B.O.P.	58.9	14.7	12.2	.	.	.	280.4
CV53	356	Broadleaf	B.O.P.	109.5	27.4	26.0	.	.	.	391.8
CV55	382	Broadleaf	Waikato	36.0	9.0	0.1	0.0	12.3	17.9	155.5
CV56	315	Broadleaf	Waikato	65.6	16.4	9.3	.	.	.	203.1
CV68	323	Other Shrub	Waikato	2.1	0.5	0.0	.	.	.	4.3
CV70	328	Pod/Brdlf	Waikato	54.5	13.6	4.5	.	.	.	209.2
CV71	374	Beech	Waikato	73.5	18.4	11.1	.	.	.	208.7
CV72	255	Beech	Man/Wan	48.1	12.0	9.9	.	.	.	133.3
CV73	372	Beech	Man/Wan	87.5	21.9	8.9	.	.	.	255.8
CV82	265	Other Shrub	Man/Wan	66.5	16.6	3.8	.	.	.	154.0
CV83	402	Beech	Man/Wan	346.4	86.6	24.0	1.7	3.0	1.3	1257.2
CV84	322	Other Shrub	Man/Wan	58.3	14.6	2.5	2.9	3.1	11.5	155.5
CV85	291	Other Shrub	Man/Wan	76.6	19.1	17.6	.	.	.	251.1
CV89	329	Other Shrub	Man/Wan	17.0	4.2	0.0	.	.	.	36.8
CW52	349	Broadleaf	B.O.P.	68.6	17.1	11.7	.	.	.	441.4
CW54	357	Planted	B.O.P.	161.0	40.2	10.9	.	.	.	651.6
CW55	340	Broadleaf	B.O.P.	178.1	44.5	29.5	.	.	.	578.9
CW57	373	Broadleaf	B.O.P.	141.5	35.4	5.2	.	.	.	463.8
CW67	325	Other Shrub	Waikato	11.4	2.8	0.0	.	.	.	25.5
CW70	366	Bch/Brdlv	Waikato	432.0	108.0	23.6	.	.	.	1595.6
CW71	273	Beech	Waikato	63.4	15.8	75.6	.	.	.	221.2
CW79	385	Bch/Pod/Brdlf	Man/Wan	165.4	41.4	37.6	2.1	4.4	21.2	549.0
CW81	260	Beech	Man/Wan	106.1	26.5	20.9	2.6	.	.	346.7
CW84	359	Other Shrub	Man/Wan	166.5	41.6	68.5	2.6	5.3	3.6	538.0
CX53	360	Planted	B.O.P.	230.7	57.7	11.6	2.5	7.5	1.6	956.0
CX56	395	Planted	B.O.P.	208.6	52.1	15.7	.	.	.	822.7
CX57	340	Pod/Brdlf	B.O.P.	201.4	50.3	20.2	.	.	.	742.0
CX59	388	Other Shrub	Waikato	143.1	35.8	22.5	.	.	.	429.8
CX69	390	Beech	Waikato	248.9	62.2	20.1	.	.	.	912.2
CX70	321	Beech	Waikato	49.8	12.5	50.5	1.9	2.2	0.3	165.0
CX71	386	Beech	Waikato	144.2	36.1	27.3	3.8	4.2	50.4	500.3
CX73	357	Beech	Man/Wan	68.6	17.2	8.1	.	.	.	213.7
CX76	393	Other Shrub	Man/Wan	30.7	7.7	0.0	.	.	.	67.2
CX77	329	Bch/Pod/Brdlf	Man/Wan	57.6	14.4	2.0	.	.	.	144.1

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CX78	337	Other Shrub	H. Bay	88.3	22.1	14.7	.	.	.	284.3
CX80	335	Beech	H. Bay	148.7	37.2	10.1	.	.	.	494.3
CX82	356	Other Shrub	H. Bay	43.5	10.9	0.4	.	.	.	98.7
CX89	361	Planted	Man/Wan	117.4	29.3	0.0	.	.	.	400.3
CY53	310	Other Shrub	B.O.P.	3.8	1.0	0.8	.	.	.	16.8
CY54	395	Broadleaf	B.O.P.	121.8	30.5	6.1	0.1	.	.	469.7
CY69	309	Beech	Waikato	93.4	23.4	71.6	.	.	.	306.0
CY70	373	Beech	Waikato	174.2	43.6	31.1	.	.	.	654.3
CY71	328	Beech	H. Bay	246.6	61.7	41.3	.	.	.	925.6
CY72	344	Beech	H. Bay	197.2	49.3	24.2	.	.	.	681.8
CY73	316	Beech	Man/Wan	55.5	13.9	8.8	0.5	3.6	21.7	171.1
CY74	326	Other Shrub	Man/Wan	41.8	10.5	0.1	.	.	.	89.4
CY75	294	Beech	Man/Wan	55.9	14.0	2.2	0.0	1.1	0.0	160.3
CY76	366	Other Shrub	Man/Wan	33.1	8.3	0.0	.	.	.	72.9
CY77	346	Other Shrub	H. Bay	28.8	7.2	0.1	0.6	4.1	14.3	57.8
CY78	289	Beech	H. Bay	57.0	14.3	0.0	.	.	.	135.4
CY80	316	Other Shrub	H. Bay	83.9	21.0	0.0	.	.	.	266.4
CZ53	324	Other Shrub	B.O.P.	14.1	3.5	0.2	.	.	.	119.9
CZ55	389	Planted	B.O.P.	106.1	26.5	1.8	0.0	2.8	7.3	403.2
CZ71	359	Beech	Waikato	98.5	24.6	3.3	2.0	4.3	2.8	358.7
CZ72	366	Beech	Waikato	72.6	18.1	74.2	.	.	.	226.0
CZ73	338	Beech	H. Bay	8.3	2.1	13.3	2.2	.	.	17.2
CZ74	349	Beech	H. Bay	102.4	25.6	12.6	.	.	.	294.4
CZ77	400	Other Shrub	H. Bay	0.0	0.0	0.0	.	.	.	0.0
CZ91	329	Other Shrub	Man/Wan	19.3	4.8	0.1	.	.	.	40.3
DA56	382	Other Shrub	B.O.P.	0.0	0.0	0.0	.	.	.	0.0
DA57	385	Other Shrub	B.O.P.	192.0	48.0	211.8	.	.	.	683.4
DA58	388	Broadleaf	B.O.P.	80.2	20.1	23.4	0.7	6.2	1.5	398.8
DA59	380	Unsp Indg	B.O.P.	12.5	3.1	0.2	.	.	.	93.6
DA70	385	Beech	H. Bay	1.1	0.3	0.0	0.0	.	.	1.9
DA71	340	Other Shrub	H. Bay	182.1	45.5	12.2	.	.	.	650.3
DA73	343	Unsp Indg	H. Bay	60.4	15.1	0.3	.	.	.	152.3
DA74	328	Other Shrub	H. Bay	56.7	14.2	0.0	.	.	.	159.8
DA75	293	Other Shrub	H. Bay	116.9	29.2	6.4	.	.	.	295.3
DB58	336	Pod/Brdlf	B.O.P.	107.5	26.9	32.7	.	.	.	319.8
DB68	350	Other Shrub	Waikato	1.1	0.3	0.0	.	.	.	2.7
DB69	324	Other Shrub	Waikato	28.1	7.0	1.0	.	.	.	63.1
DB71	353	Beech	H. Bay	172.5	43.1	17.8	.	.	.	616.8
DB74	322	Other Shrub	H. Bay	47.0	11.8	0.0	0.0	1.5	0.5	109.3
DB86	380	Other Shrub	H. Bay	0.0	0.0	0.0	0.0	0.5	0.0	0.1
DC56	394	Pod/Brdlf	B.O.P.	121.4	30.3	12.4	0.0	3.6	4.2	528.6
DC66	367	Pod/Brdlf	Waikato	146.9	36.7	6.3	.	.	.	518.7
DC67	323	Pod/Brdlv/Bch	Waikato	124.1	31.0	77.5	.	.	.	442.3
DC68	338	Beech	Waikato	77.2	19.3	11.1	.	.	.	223.4
DC69	289	Beech	H. Bay	140.6	35.1	17.3	0.1	3.0	54.9	468.5
DC70	313	Beech	H. Bay	247.6	61.9	6.3	.	.	.	764.5
DD63	367	Other Shrub	B.O.P.	0.0	0.0	0.0	0.5	2.1	0.7	0.0
DD64	344	Other Shrub	B.O.P.	185.8	46.4	43.9	.	.	.	667.6
DD65	367	Pod/Brdlf	B.O.P.	442.5	110.6	19.6	.	.	.	1584.5
DD66	363	Pod/Brdlf	B.O.P.	269.0	67.3	9.9	.	.	.	1071.7

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DD67	327	Bch/Pod/Brdlf	H. Bay	256.6	64.1	22.4	.	.	.	827.2
DD68	311	Beech	H. Bay	111.7	27.9	32.0	0.3	.	.	375.1
DD69	342	Beech	H. Bay	41.3	10.3	7.1	.	.	.	101.1
DD70	349	Beech	H. Bay	306.0	76.5	32.7	.	.	.	1087.1
DE63	360	Pod/Brdlv/Bch	B.O.P.	249.4	62.3	5.2	0.0	4.2	7.5	909.8
DE64	368	Other Shrub	B.O.P.	14.6	3.7	6.0	.	.	.	48.7
DE65	327	Pod/Brdlf	B.O.P.	197.4	49.3	24.5	.	.	.	715.5
DE66	357	Bch/Pod/Brdlf	H. Bay	203.4	50.9	32.6	.	.	.	700.3
DE68	358	Bch/Pod/Brdlf	H. Bay	193.1	48.3	27.9	1.7	3.8	29.8	700.9
DE69	312	Pod/Brdlf	H. Bay	64.0	16.0	5.7	.	.	.	230.7
DE70	333	Other Shrub	H. Bay	68.5	17.1	0.6	.	.	.	206.4
DF59	332	Pod/Brdlf	B.O.P.	259.7	64.9	34.6	.	.	.	915.4
DF60	280	Pod/Brdlf	B.O.P.	125.6	31.4	9.0	0.0	6.9	14.9	407.3
DF61	361	Pod/Brdlv/Bch	B.O.P.	227.3	56.8	12.1	.	.	.	731.7
DF62	236	Pod/Brdlv/Bch	B.O.P.	172.9	43.2	24.3	.	.	.	540.4
DF63	244	Pod/Brdlv/Bch	B.O.P.	200.4	50.1	10.9	.	.	.	652.6
DF64	355	Bch/Pod/Brdlf	B.O.P.	326.9	81.7	24.7	.	.	.	1186.3
DF65	387	Other Shrub	B.O.P.	0.2	0.1	0.0	0.0	2.0	0.0	0.5
DF66	324	Pod/Brdlf	H. Bay	65.4	16.4	21.2	.	.	.	373.2
DF67	317	Beech	H. Bay	74.0	18.5	51.2	0.2	.	.	333.4
DF68	343	Bch/Pod/Brdlf	H. Bay	144.0	36.0	15.1	.	.	.	404.3
DG59	347	Pod/Brdlf	B.O.P.	274.5	68.6	0.1	.	.	.	932.8
DG60	271	Pod/Brdlf	B.O.P.	199.7	49.9	18.0	.	.	.	641.5
DG61	378	Pod/Brdlf	B.O.P.	203.3	50.8	2.9	.	.	.	639.2
DG62	372	Broadleaf	B.O.P.	197.0	49.2	18.1	.	.	.	659.4
DG63	384	Pod/Brdlf	B.O.P.	302.5	75.6	73.8	.	.	.	1014.9
DG64	306	Broadleaf	B.O.P.	24.5	6.1	0.4	.	.	.	64.5
DG65	284	Beech	B.O.P.	62.8	15.7	62.6	0.1	4.6	3.9	367.3
DG66	80	Beech	H. Bay	78.7	19.7	27.9	10.9	.	.	241.4
DG67	326	Bch/Pod/Brdlf	H. Bay	231.9	58.0	18.6	.	.	.	700.7
DH58	288	Broadleaf	B.O.P.	13.7	3.4	0.0	.	.	.	155.0
DH59	275	Pod/Brdlf	B.O.P.	17.7	4.4	2.1	.	.	.	163.3
DH60	301	Pod/Brdlf	B.O.P.	31.4	7.8	23.8	.	.	.	149.0
DH61	318	Pod/Brdlf	B.O.P.	55.8	13.9	13.5	.	.	.	187.1
DH62	363	Pod/Brdlf	B.O.P.	226.6	56.6	19.5	1.7	6.3	13.3	731.5
DH63	250	Pod/Brdlf	B.O.P.	50.3	12.6	14.0	.	.	.	202.3
DH64	348	Pod/Brdlv/Bch	B.O.P.	273.1	68.3	30.3	.	.	.	994.1
DH65	300	Bch/Pod/Brdlf	H. Bay	159.7	39.9	33.0	.	.	.	590.7
DH66	301	Bch/Pod/Brdlf	H. Bay	326.0	81.5	17.4	.	.	.	1004.7
DH68	393	Bch/Brdlv	H. Bay	176.6	44.2	1.3	.	.	.	564.6
DH70	374	Other Shrub	H. Bay	0.0	0.0	0.0	.	.	.	0.0
DI56	400	Other Shrub	B.O.P.	0.0	0.0	0.0	.	.	.	0.0
DI57	289	Other Shrub	B.O.P.	58.5	14.6	0.5	.	.	.	243.2
DI60	279	Pod/Brdlf	B.O.P.	127.7	31.9	4.4	0.0	3.2	0.4	415.1
DI61	335	Pod/Brdlv/Bch	B.O.P.	107.7	26.9	5.3	1.8	4.2	21.8	366.2
DI62	327	Pod/Brdlv/Bch	B.O.P.	627.7	156.9	67.4	1.0	3.7	12.1	1817.9
DI63	276	Pod/Brdlf	B.O.P.	195.4	48.8	22.0	.	.	.	647.6
DI64	369	Beech	B.O.P.	183.3	45.8	26.9	1.3	6.4	30.8	620.4
DI65	368	Beech	H. Bay	300.4	75.1	17.7	.	.	.	1103.2
DI66	395	Beech	H. Bay	192.5	48.1	49.9	.	.	.	690.2

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DI67	348	Beech	H. Bay	206.3	51.6	36.2	.	.	.	712.7
DJ58	355	Pod/Brdlv/Bch	B.O.P.	172.2	43.0	7.9	0.6	4.6	10.5	522.2
DJ59	321	Pod/Brdlv/Bch	B.O.P.	169.1	42.3	54.5	0.0	.	.	508.6
DJ60	280	Pod/Brdlv/Bch	B.O.P.	106.1	26.5	23.2	.	.	.	427.9
DJ61	357	Bch/Pod/Brdlf	B.O.P.	286.4	71.6	14.3	.	.	.	993.2
DJ62	295	Pod/Brdlv/Bch	B.O.P.	154.4	38.6	6.7	.	.	.	536.3
DJ63	375	Beech	B.O.P.	35.6	8.9	16.1	0.0	3.5	5.7	363.9
DJ64	357	Beech	Gisborne	272.7	68.2	29.7	4.7	.	.	943.4
DJ65	316	Beech	Gisborne	208.7	52.2	31.5	1.1	4.4	41.6	691.2
DJ66	314	Bch/Pod/Brdlf	H. Bay	147.5	36.9	60.5	0.5	6.0	48.1	526.2
DJ68	299	Other Shrub	H. Bay	0.0	0.0	0.0	0.0	0.2	0.0	0.0
DK58	311	Pod/Brdlf	B.O.P.	79.1	19.8	10.2	.	.	.	269.6
DK59	289	Pod/Brdlv/Bch	B.O.P.	75.8	18.9	17.2	.	.	.	284.9
DK60	313	Other Shrub	B.O.P.	30.1	7.5	3.1	.	.	.	214.2
DK61	379	Pod/Brdlv/Bch	B.O.P.	92.4	23.1	19.1	0.1	6.0	27.0	430.6
DK63	374	Beech	Gisborne	318.4	79.6	44.2	.	.	.	1176.6
DK64	361	Beech	Gisborne	171.6	42.9	28.0	.	.	.	592.6
DL57	321	Unsp Indg	B.O.P.	121.0	30.2	6.6	1.4	5.5	20.5	457.5
DL60	274	Pod/Brdlv/Bch	B.O.P.	220.3	55.1	19.7	.	.	.	781.9
DL61	303	Other Shrub	B.O.P.	124.0	31.0	3.2	.	.	.	398.2
DL62	347	Pod/Brdlv/Bch	Gisborne	57.5	14.4	24.9	.	.	.	152.7
DM57	271	Pod/Brdlv/Bch	B.O.P.	100.7	25.2	13.9	.	.	.	321.6
DM58	348	Pod/Brdlv/Bch	B.O.P.	187.2	46.8	13.5	0.7	.	.	655.5
DM59	282	Pod/Brdlv/Bch	B.O.P.	117.8	29.5	14.1	.	.	.	373.9
DM62	370	Other Shrub	Gisborne	0.9	0.2	2.8	.	.	.	1.8
DM65	323	Other Shrub	Gisborne	91.9	23.0	1.0	0.8	4.0	0.2	302.4
DM68	351	Planted	H. Bay	70.6	17.7	1.1	.	.	.	252.0
DN56	291	Pod/Brdlv/Bch	B.O.P.	74.2	18.5	31.8	.	.	.	243.1
DN58	344	Other Shrub	B.O.P.	86.4	21.6	15.3	.	.	.	298.7
DN61	308	Other Shrub	Gisborne	64.7	16.2	26.4	1.0	4.0	20.3	167.8
DO54	339	Bch/Brdlv	B.O.P.	112.5	28.1	4.0	1.0	4.8	14.5	367.9
DO56	292	Pod/Brdlv/Bch	B.O.P.	152.6	38.1	24.5	.	.	.	458.9
DO57	283	Pod/Brdlv/Bch	B.O.P.	172.0	43.0	24.8	.	.	.	544.0
DO58	297	Pod/Brdlv/Bch	Gisborne	118.0	29.5	9.5	0.3	4.4	5.0	399.1
DO59	338	Pod/Brdlf	Gisborne	67.3	16.8	9.3	.	.	.	538.4
DO63	373	Other Shrub	Gisborne	55.4	13.9	9.3	.	.	.	152.7
DP53	308	Pod/Brdlv/Bch	B.O.P.	138.8	34.7	56.0	.	.	.	438.5
DP54	327	Pod/Brdlv/Bch	B.O.P.	157.9	39.5	25.7	.	.	.	466.4
DP55	247	Pod/Brdlv/Bch	B.O.P.	224.8	56.2	10.8	.	.	.	701.5
DP56	386	Pod/Brdlv/Bch	B.O.P.	114.0	28.5	29.4	.	.	.	399.0
DP57	296	Bch/Pod/Brdlf	B.O.P.	147.6	36.9	36.5	0.3	.	.	455.6
DP58	271	Pod/Brdlf	Gisborne	149.1	37.3	7.0	0.1	1.6	0.0	491.8
DP59	379	Pod/Brdlf	Gisborne	182.2	45.5	22.7	0.0	.	.	646.8
DP62	353	Other Shrub	Gisborne	0.0	0.0	0.0	0.0	0.2	0.0	0.0
DP66	352	Other Shrub	Gisborne	75.3	18.8	0.0	0.9	.	.	189.1
DP68	376	Other Shrub	Gisborne	0.0	0.0	0.0	0.0	0.6	0.0	0.0
DQ52	329	Other Shrub	B.O.P.	12.1	3.0	0.7	.	.	.	28.2
DQ53	353	Pod/Brdlv/Bch	B.O.P.	58.1	14.5	6.8	.	.	.	225.0
DQ54	269	Pod/Brdlv/Bch	B.O.P.	103.1	25.8	1.6	1.9	3.2	0.0	323.9
DQ55	348	Pod/Brdlv/Bch	B.O.P.	101.9	25.5	16.3	.	.	.	254.1

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DQ56	334	Pod/Brdlv/Bch	B.O.P.	159.4	39.9	18.2	.	.	.	572.3
DQ57	310	Bch/Pod/Brdlf	B.O.P.	60.5	15.1	1.9	.	.	.	254.4
DQ58	308	Beech	B.O.P.	162.4	40.6	26.7	.	.	.	491.6
DR52	400	Other Shrub	B.O.P.	0.0	0.0	0.0	0.0	.	.	0.0
DR53	288	Pod/Brdlv/Bch	B.O.P.	70.9	17.7	43.3	.	.	.	330.4
DR54	288	Pod/Brdlv/Bch	B.O.P.	162.0	40.5	30.7	.	.	.	493.1
DR55	291	Pod/Brdlv/Bch	B.O.P.	69.0	17.3	8.6	1.1	3.4	1.0	173.3
DR56	376	Beech	Gisborne	99.3	24.8	6.6	0.0	1.3	0.2	301.4
DR57	315	Pod/Brdlf	Gisborne	165.6	41.4	3.4	.	.	.	556.9
DS51	317	Unsp Indg	B.O.P.	58.3	14.6	1.3	.	.	.	180.0
DS52	317	Unsp Indg	Gisborne	58.3	14.6	7.7	.	.	.	221.5
DS54	338	Pod/Brdlf	B.O.P.	106.3	26.6	15.3	.	.	.	292.7
DS55	277	Beech	Gisborne	243.9	61.0	11.6	0.2	4.5	0.0	829.7
DS56	353	Other Shrub	Gisborne	346.9	86.7	24.4	.	.	.	1181.9
DS60	385	Other Shrub	Gisborne	0.0	0.0	0.0	0.0	.	.	0.0
DT56	294	Beech	Gisborne	19.9	5.0	2.7	1.2	.	.	84.9
DT58	368	Planted	Gisborne	29.0	7.2	0.0	0.0	1.9	1.3	75.0
DU51	352	Other Shrub	Gisborne	26.9	6.7	0.3	.	.	.	61.5
DU52	373	Unsp Indg	Gisborne	105.4	26.4	10.3	.	.	.	420.3
DU57	375	Other Shrub	Gisborne	12.4	3.1	0.0	0.0	2.9	1.0	26.5
DU60	328	Other Shrub	Gisborne	33.9	8.5	0.3	.	.	.	77.4
DV52	273	Unsp Indg	Gisborne	169.4	42.3	8.4	0.4	3.3	0.0	487.0
DV57	384	Other Shrub	Gisborne	103.3	25.8	2.1	.	.	.	283.8
DV58	387	Other Shrub	Gisborne	17.8	4.4	0.0	.	.	.	40.2
DV59	312	Other Shrub	Gisborne	38.4	9.6	0.4	0.0	4.1	0.0	88.1
DW52	338	Other Shrub	Gisborne	80.8	20.2	0.4	.	.	.	223.2
DW53	310	Other Shrub	Gisborne	45.5	11.4	3.5	.	.	.	202.2
DW54	380	Other Shrub	Gisborne	87.0	21.7	10.1	1.0	1.6	8.0	295.3
DX53	389	Other Shrub	Gisborne	20.3	5.1	0.2	0.0	1.8	0.0	43.8
E166	365	Bch/Pod/Brdlf	Southland	212.1	53.0	7.5	.	.	.	660.8
E167	325	Bch/Pod/Brdlf	Southland	147.1	36.8	18.2	.	2.8	17.7	444.1
E168	312	Bch/Pod/Brdlf	Southland	119.1	29.8	21.1	.	2.1	51.5	403.2
F164	352	Pod/Brdlv/Bch	Southland	71.3	17.8	5.7	.	.	.	151.0
F166	301	Bch/Pod/Brdlf	Southland	141.8	35.5	3.1	.	.	.	448.7
F169	351	Bch/Pod/Brdlf	Southland	182.2	45.6	11.0	.	.	.	577.2
G161	373	Bch/Brdlv	Southland	221.8	55.4	5.5	.	.	.	659.8
G162	332	Bch/Pod/Brdlf	Southland	285.8	71.5	52.9	.	6.1	2.1	1019.7
G163	372	Bch/Pod/Brdlf	Southland	315.2	78.8	19.9	.	.	.	1168.9
G164	377	Bch/Pod/Brdlf	Southland	327.5	81.9	6.5	.	.	.	1185.8
G165	360	Bch/Pod/Brdlf	Southland	126.4	31.6	11.8	.	.	.	371.5
G166	332	Other Shrub	Southland	1.0	0.3	0.0	.	1.1	0.0	1.7
G167	325	Bch/Pod/Brdlf	Southland	84.2	21.1	26.7	.	.	.	251.3
G169	300	Bch/Pod/Brdlf	Southland	60.0	15.0	1.3	.	.	.	126.0
H158	391	Bch/Pod/Brdlf	Southland	465.1	116.3	19.2	.	.	.	1409.6
H159	366	Pod/Brdlv/Bch	Southland	153.1	38.3	8.3	.	.	.	534.8
H160	298	Bch/Pod/Brdlf	Southland	298.2	74.6	9.8	.	.	.	997.6
H161	327	Beech	Southland	118.0	29.5	13.0	.	1.3	3.0	318.3
H163	230	Bch/Pod/Brdlf	Southland	266.1	66.5	2.2	.	.	.	857.4
H164	295	Other Shrub	Southland	59.8	14.9	0.7	.	.	.	159.9
H167	294	Bch/Brdlv	Southland	111.5	27.9	8.6	.	.	.	342.6

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H168	353	Bch/Pod/Brdlf	Southland	363.3	90.8	38.3	.	.	.	1409.0
H170	389	Bch/Pod/Brdlf	Southland	243.0	60.8	18.9	.	.	.	772.3
H171	367	Bch/Pod/Brdlf	Southland	90.9	22.7	5.8	.	3.0	54.0	179.4
I157	342	Beech	Southland	171.5	42.9	37.6	.	.	.	556.4
I158	371	Bch/Pod/Brdlf	Southland	112.0	28.0	1.9	.	.	.	247.7
I160	313	Bch/Pod/Brdlf	Southland	136.7	34.2	8.3	.	.	.	436.3
I161	293	Beech	Southland	11.3	2.8	21.5	.	.	.	35.1
I164	327	Bch/Pod/Brdlf	Southland	105.4	26.4	13.2	.	3.4	0.0	281.3
I165	290	Bch/Pod/Brdlf	Southland	0.0	0.0	0.0	.	.	.	0.0
I166	392	Bch/Brdlv	Southland	212.3	53.1	22.9	.	.	.	722.1
I167	282	Bch/Pod/Brdlf	Southland	179.7	44.9	9.5	.	.	.	624.6
I171	370	Bch/Pod/Brdlf	Southland	135.2	33.8	14.9	.	.	.	302.3
J155	305	Beech	Southland	204.1	51.0	11.9	.	.	.	549.5
J156	285	Beech	Southland	158.5	39.6	12.0	.	.	.	470.0
J157	317	Beech	Southland	137.4	34.4	6.1	.	.	.	423.2
J158	284	Other Shrub	Southland	48.2	12.1	0.6	.	.	.	141.3
J164	264	Bch/Pod/Brdlf	Southland	270.2	67.5	59.4	.	.	.	881.3
J169	289	Beech	Southland	198.3	49.6	33.9	.	.	.	648.9
J170	399	Bch/Brdlv	Southland	170.6	42.7	3.5	.	.	.	498.2
J171	367	Pod/Brdlv/Bch	Southland	109.6	27.4	21.9	.	.	.	293.1
K153	285	Beech	Southland	147.3	36.8	38.3	.	4.7	0.9	525.6
K154	290	Beech	Southland	73.1	18.3	37.5	.	.	.	244.8
K155	329	Beech	Southland	152.2	38.1	5.9	.	2.1	22.3	471.6
K156	321	Beech	Southland	158.0	39.5	4.4	.	.	.	531.2
K157	387	Beech	Southland	141.6	35.4	20.8	.	.	.	461.4
K158	359	Beech	Southland	87.1	21.8	3.1	.	2.2	16.9	213.9
K160	338	Beech	Southland	0.0	0.0	0.0	.	.	.	0.0
K161	380	Bch/Brdlv	Southland	160.9	40.2	9.0	.	.	.	524.6
K163	382	Beech	Southland	150.5	37.6	3.4	.	.	.	478.8
K166	330	Bch/Brdlv	Southland	211.1	52.8	36.4	.	.	.	715.4
K169	305	Beech	Southland	60.4	15.1	1.8	.	3.3	12.0	131.3
K171	322	Bch/Pod/Brdlf	Southland	278.9	69.7	7.8	.	.	.	947.6
L153	282	Beech	Southland	229.2	57.3	11.6	.	.	.	557.9
L155	373	Beech	Southland	162.2	40.5	11.8	.	.	.	582.5
L157	299	Beech	Southland	141.4	35.3	10.3	.	.	.	460.3
L158	256	Other Shrub	Southland	0.0	0.0	0.0	.	.	.	0.0
L161	390	Beech	Southland	193.6	48.4	16.4	.	.	.	693.5
L163	393	Other Shrub	Southland	66.1	16.5	3.7	.	1.1	4.1	192.2
L164	271	Beech	Southland	171.2	42.8	40.8	.	.	.	554.5
L166	315	Beech	Southland	157.3	39.3	24.0	.	3.7	39.5	474.9
L168	347	Beech	Southland	200.3	50.1	11.3	.	.	.	710.3
L169	335	Bch/Pod/Brdlf	Southland	176.0	44.0	32.3	.	7.8	.	571.2
L170	344	Bch/Pod/Brdlf	Southland	210.8	52.7	14.1	.	5.7	17.1	660.0
L171	379	Pod/Brdlv/Bch	Southland	101.7	25.4	5.7	.	3.5	1.9	297.1
M152	349	Beech	Southland	186.6	46.7	73.9	.	.	.	641.9
M153	299	Beech	Southland	17.2	4.3	0.2	.	.	.	37.2
M154	321	Beech	Southland	129.8	32.5	9.1	.	.	.	417.5
M158	397	Beech	Southland	66.2	16.5	7.4	.	1.4	0.0	186.3
M162	255	Beech	Southland	104.4	26.1	10.6	.	.	.	301.2
M163	297	Beech	Southland	213.7	53.4	47.3	.	5.5	7.7	739.7

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M169	386	Bch/Pod/Brdlf	Southland	94.0	23.5	50.6	.	.	.	310.7
M170	329	Beech	Southland	115.5	28.9	3.1	.	.	.	321.9
M171	358	Bch/Pod/Brdlf	Southland	131.1	32.8	7.6	.	4.4	2.5	468.5
N150	318	Bch/Pod/Brdlf	Southland	99.7	24.9	35.9	.	.	.	395.4
N155	330	Beech	Southland	194.7	48.7	38.1	.	.	.	652.6
N156	316	Other Shrub	Southland	102.1	25.5	72.0	.	.	.	292.9
N157	320	Beech	Southland	139.3	34.8	23.9	.	.	.	421.4
N158	354	Beech	Southland	245.6	61.4	40.4	.	.	.	862.5
N159	291	Beech	Southland	217.5	54.4	24.9	.	.	.	753.7
N160	306	Beech	Southland	174.0	43.5	5.1	.	.	.	586.8
N163	290	Beech	Southland	176.7	44.2	10.0	.	.	.	493.9
N164	367	Beech	Southland	136.4	34.1	11.5	.	.	.	367.4
N165	366	Beech	Southland	206.4	51.6	24.1	.	4.5	21.3	691.1
N166	367	Bch/Pod/Brdlf	Southland	250.1	62.5	39.5	.	.	.	904.0
N167	366	Beech	Southland	192.7	48.2	36.5	.	.	.	679.9
N168	386	Bch/Pod/Brdlf	Southland	177.0	44.2	26.2	.	3.0	29.1	564.2
N169	325	Bch/Pod/Brdlf	Southland	124.1	31.0	53.0	.	.	.	435.1
N170	330	Pod/Brdlv/Bch	Southland	55.2	13.8	42.8	.	.	.	225.4
O149	366	Bch/Pod/Brdlf	Southland	167.9	42.0	15.7	.	.	.	447.2
O150	372	Bch/Pod/Brdlf	Southland	111.8	28.0	4.8	.	5.4	2.3	378.3
O151	340	Beech	Southland	227.9	57.0	15.2	.	.	.	797.1
O152	325	Beech	Southland	219.5	54.9	49.9	.	.	.	632.9
O153	304	Beech	Southland	0.0	0.0	0.0	.	1.2	0.0	0.0
O155	391	Beech	Southland	149.5	37.4	11.9	.	5.9	9.6	494.1
O158	285	Beech	Southland	196.8	49.2	4.4	.	.	.	627.3
O160	365	Beech	Southland	197.5	49.4	42.4	.	5.9	21.5	641.7
O162	390	Bch/Pod/Brdlf	Southland	289.6	72.4	53.5	.	.	.	931.3
O163	379	Bch/Pod/Brdlf	Southland	246.9	61.7	9.0	.	.	.	869.9
O164	378	Bch/Pod/Brdlf	Southland	113.0	28.3	34.7	.	.	.	372.3
O166	350	Bch/Pod/Brdlf	Southland	190.6	47.6	21.2	.	.	.	628.2
O167	332	Bch/Pod/Brdlf	Southland	264.4	66.1	11.2	.	9.4	8.1	963.8
O169	335	Bch/Pod/Brdlf	Southland	226.5	56.6	13.3	.	.	.	821.1
O170	387	Other Shrub	Southland	0.2	0.1	37.9	.	.	.	4.0
P154	296	Other Shrub	Southland	24.2	6.0	0.0	.	.	.	58.0
P155	321	Beech	Southland	175.3	43.8	10.1	.	.	.	553.2
P156	354	Beech	Southland	201.3	50.3	66.2	.	.	.	716.3
P158	351	Bch/Pod/Brdlf	Southland	166.9	41.7	41.9	.	.	.	591.1
P162	400	Other Shrub	Southland	0.1	0.0	0.0	.	2.1	0.0	0.2
P166	350	Unsp Indg	Southland	32.2	8.0	0.7	.	.	.	80.7
P168	360	Bch/Pod/Brdlf	Southland	60.7	15.2	1.0	.	.	.	153.1
P169	357	Bch/Pod/Brdlf	Southland	196.1	49.0	19.1	.	.	.	695.4
P185	339	SubalpShrub	Southland	20.1	5.0	1.0	.	0.8	.	36.7
Q146	378	Pod/Brdlf	Southland	262.7	65.7	4.9	.	4.9	67.0	932.8
Q147	381	Pod/Brdlf	Southland	222.8	55.7	12.1	.	.	.	773.0
Q149	264	SubalpShrub	Southland	140.6	35.2	4.5	.	.	.	356.1
Q150	270	Other Shrub	Southland	3.0	0.8	0.0	.	.	.	7.1
Q151	320	SubalpShrub	Southland	11.5	2.9	2.3	.	.	.	24.6
Q153	315	Beech	Southland	223.6	55.9	8.5	.	.	.	776.4
Q154	315	Beech	Southland	50.0	12.5	3.3	.	1.0	.	119.6
Q156	394	Other Shrub	Southland	41.3	10.3	0.0	.	3.6	5.3	108.7

CMSID	Inner Plot Area (m^2)	Modified EcoSat Type	Region	AGB (t/ha)	BGB (t/ha)	CWD (t/ha)	FWD (t/ha)	Litter (t/ha)	FH(O) (t/ha)	Stem Volume (m^3/ha)
Q157	400	Other Shrub	Southland	0.0	0.0	0.0	.	0.3	0.0	0.0
Q158	370	Beech	Southland	70.2	17.5	31.4	.	.	.	238.0
Q165	349	Other Shrub	Southland	1.2	0.3	0.0	.	.	.	2.4
Q171	370	Pod/Brdlv/Bch	Southland	184.2	46.0	14.7	.	.	.	595.3
Q181	379	Other Shrub	Southland	43.6	10.9	15.0	.	18.3	0.0	105.0
Q183	397	Other Shrub	Southland	0.0	0.0	0.0	.	0.2	0.0	0.0
Q184	349	Pod/Brdlf	Southland	134.8	33.7	2.6	.	.	.	305.3
Q185	394	Other Shrub	Southland	38.0	9.5	17.9	.	.	.	98.2
R146	385	Bch/Pod/Brdlf	Southland	172.8	43.2	17.1	.	.	.	513.0
R147	367	Beech	Southland	317.4	79.4	29.7	.	.	.	865.3
R149	373	Beech	Southland	148.1	37.0	5.9	.	.	.	503.2
R152	347	Beech	Southland	254.6	63.6	12.2	.	4.4	13.8	893.2
R153	348	Other Shrub	Southland	0.0	0.0	0.0	.	.	.	0.0
R154	311	Beech	Southland	134.1	33.5	9.5	.	.	.	369.3
R155	320	Beech	Southland	143.4	35.8	32.5	.	.	.	473.8
R158	383	Beech	Southland	155.1	38.8	4.1	.	4.8	.	470.3
R159	379	Beech	Southland	189.3	47.3	28.8	.	3.3	30.6	685.6
R170	378	Bch/Pod/Brdlf	Southland	219.9	55.0	33.0	.	7.0	13.9	773.6
R171	381	Pod/Brdlv/Bch	Southland	371.4	92.8	20.6	.	.	.	1094.9
R172	397	Pod/Brdlv/Bch	Southland	91.7	22.9	23.9	.	.	.	309.2
R178	360	Pod/Brdlf	Southland	262.5	65.6	35.2	.	.	.	761.9
R179	297	Other Shrub	Southland	43.0	10.7	0.5	.	.	.	96.4
R180	392	Pod/Brdlf	Southland	58.1	14.5	1.2	.	.	.	160.8
R181	319	Pod/Brdlf	Southland	169.9	42.5	5.5	.	.	.	459.3
R182	387	Other Shrub	Southland	56.5	14.1	6.9	.	.	.	126.5
R183	364	SubalpShrub	Southland	40.7	10.2	3.4	.	.	.	80.6
R184	380	SubalpShrub	Southland	87.8	21.9	4.2	.	.	.	201.1
S145	404	Pod/Brdlf	Southland	173.7	43.4	16.9	.	.	.	612.2
S147	272	Beech	Southland	118.0	29.5	17.5	.	.	.	315.6
S148	310	Beech	Southland	236.9	59.2	26.3	.	.	.	804.0
S149	296	Other Shrub	Southland	0.0	0.0	0.0	.	4.3	0.0	0.0
S156	365	Beech	Southland	137.5	34.4	38.3	.	.	.	446.7
S157	356	Beech	Southland	127.4	31.9	28.8	.	.	.	410.3
S158	391	Beech	Southland	0.0	0.0	0.0	.	.	.	0.0
S159	370	Beech	Southland	150.4	37.6	24.6	.	.	.	499.0
S160	364	Beech	Southland	116.3	29.1	26.1	.	.	.	394.4
S163	345	Unsp Indg	Southland	122.3	30.6	4.9	.	5.5	30.4	395.1
S179	326	Other Shrub	Southland	53.5	13.4	5.8	.	3.3	0.0	124.3
S180	366	Pod/Brdlf	Southland	95.7	23.9	23.5	.	.	.	263.4
S181	376	Pod/Brdlf	Southland	213.8	53.4	5.3	.	.	.	702.7
S182	383	SubalpShrub	Southland	54.2	13.6	2.5	.	.	.	110.1
S183	391	SubalpShrub	Southland	18.5	4.6	2.0	.	1.4	70.9	33.2
S184	334	Pod/Brdlf	Southland	138.3	34.6	3.8	.	5.8	0.0	377.3
T143	316	Beech	West C.	254.1	63.5	24.0	.	.	.	821.5
T144	406	Bch/Pod/Brdlf	Southland	239.9	60.0	8.9	.	3.5	10.2	1038.3
T145	376	Beech	Southland	69.9	17.5	5.5	.	.	.	268.2
T146	353	Bch/Pod/Brdlf	Southland	152.2	38.1	13.2	.	.	.	524.6
T147	379	Beech	Southland	200.7	50.2	21.0	.	2.9	23.0	662.4
T155	367	Other Shrub	Southland	172.9	43.2	7.2	.	.	.	568.6
T159	344	Unsp Indg	Southland	94.6	23.6	12.3	.	.	.	279.7

CMSID	Inner Plot Area (m^2)	Modified EcoSat Type	Region	AGB (t/ha)	BGB (t/ha)	CWD (t/ha)	FWD (t/ha)	Litter (t/ha)	FH(O) (t/ha)	Stem Volume (m^3/ha)
T165	349	Other Shrub	Southland	3.1	0.8	0.0	.	.	.	6.8
T179	395	Unsp Indg	Southland	74.5	18.6	3.5	.	.	.	154.7
T180	352	Pod/Brdlf	Southland	116.3	29.1	3.0	.	.	.	359.1
T181	340	Pod/Brdlf	Southland	167.2	41.8	46.1	.	.	.	475.4
T182	385	Pod/Brdlf	Southland	125.5	31.4	2.6	.	.	.	262.9
T183	339	Pod/Brdlf	Southland	147.3	36.8	34.6	.	.	.	465.9
U141	391	Pod/Brdlf	West C.	68.5	17.1	7.3	.	1.7	0.8	417.9
U142	385	Other Shrub	West C.	2.5	0.6	0.0	.	.	.	3.8
U143	372	Other Shrub	West C.	2.3	0.6	0.0	.	.	.	3.8
U144	391	Beech	Southland	128.6	32.2	6.9	.	.	.	415.2
U152	349	Beech	Otago	166.6	41.7	4.7	.	.	.	553.4
U153	371	Beech	Otago	205.6	51.4	12.7	.	5.4	14.0	676.3
U159	381	Beech	Southland	221.1	55.3	8.7	.	6.9	45.9	700.1
U160	366	Beech	Southland	226.4	56.6	19.1	.	.	.	730.3
U161	366	Beech	Southland	139.8	35.0	4.3	.	.	.	443.2
U180	364	Pod/Brdlf	Southland	129.7	32.4	1.0	.	.	.	434.4
U181	379	Pod/Brdlf	Southland	193.1	48.3	7.6	.	.	.	559.5
U182	356	Other Shrub	Southland	135.9	34.0	64.3	.	.	.	451.9
V141	301	Bch/Pod/Brdlf	West C.	269.7	67.4	13.3	.	.	.	821.3
V143	398	Pod/Brdlf	West C.	154.3	38.6	78.7	.	4.1	3.5	607.0
V147	354	Beech	Otago	101.5	25.4	35.4	.	1.5	8.6	323.1
V155	380	Other Shrub	Otago	0.0	0.0	0.0	.	0.0	17.7	0.0
V161	378	Beech	Southland	149.9	37.5	18.7	.	11.7	9.7	461.0
V182	385	Other Shrub	Southland	89.3	22.3	3.6	.	3.5	119.5	311.6
W140	339	Bch/Pod/Brdlf	West C.	60.6	15.1	2.1	.	.	.	114.5
W145	279	SubalpShrub	West C.	0.0	0.0	0.0	.	1.6	10.5	0.0
W147	333	Beech	Otago	158.6	39.7	15.8	.	.	.	569.1
W148	339	Beech	Otago	164.3	41.1	8.0	.	3.0	40.7	529.9
W154	325	Other Shrub	Otago	0.0	0.0	0.0	.	4.4	0.0	0.0
W158	289	Unsp Indg	Otago	0.0	0.0	0.0	.	.	.	0.0
W159	335	Beech	Southland	90.0	22.5	4.2	.	.	.	283.4
W167	339	Other Shrub	Southland	0.0	1.9	0.0	.	.	.	19.9
W175	394	Other Shrub	Southland	0.0	0.0	0.0	.	.	.	0.0
W176	360	Other Shrub	Southland	0.0	0.0	0.0	.	6.1	14.4	0.0
X140	317	Pod/Brdlv/Bch	West C.	199.2	49.8	15.7	.	.	.	684.3
X141	396	Beech	West C.	209.4	52.4	40.1	.	.	.	752.2
X143	288	Beech	West C.	233.5	58.4	42.6	.	.	.	933.4
X144	353	Beech	West C.	298.8	74.7	20.8	.	.	.	1239.8
X152	297	Beech	Otago	103.7	25.9	7.7	.	.	.	334.0
X154	212	Other Shrub	Otago	2.8	0.7	0.0	.	.	.	5.9
X161	375	Other Shrub	Southland	0.0	0.0	0.0	.	.	.	0.0
X168	355	Pod/Brdlf	Southland	69.0	17.3	5.7	.	.	.	186.0
Y140	382	Pod/Brdlf	West C.	105.8	26.4	4.5	.	.	.	312.3
Y141	381	Bch/Pod/Brdlf	West C.	161.0	40.2	29.0	.	.	.	584.7
Y142	299	Beech	West C.	156.0	39.0	28.6	.	.	.	566.1
Y143	323	Beech	West C.	300.0	75.0	21.4	.	.	.	1037.0
Y151	318	Beech	Otago	89.2	22.3	23.2	.	8.6	16.5	272.4
Y162	301	Other Shrub	Southland	0.0	0.0	0.0	.	.	.	0.0
Z139	379	Other Shrub	West C.	36.5	9.1	1.3	.	.	.	88.9
Z140	291	Bch/Pod/Brdlf	West C.	99.7	24.9	30.8	.	3.7	4.2	322.4

CMSID	Inner Plot Area (m^2)	Modified EcoSat Type	Region	AGB (t/ha)	BGB (t/ha)	CWD (t/ha)	FWD (t/ha)	Litter (t/ha)	FH(O) (t/ha)	Stem Volume (m^3/ha)
Z141	396	Pod/Brdlf	West C.	118.7	29.7	9.2	.	.	.	396.5
Z143	391	SubalpShrub	West C.	4.6	1.2	0.0	.	.	.	9.6
Z145	356	Beech	Otago	114.9	28.7	4.0	.	.	.	360.6
Z154	386	Other Shrub	Otago	40.4	10.1	1.3	.	.	.	139.1
Z156	362	Other Shrub	Otago	0.0	0.0	0.0	.	.	.	0.0
Z163	376	Unsp Indg	Southland	120.7	30.2	6.1	.	.	.	399.5
Z169	384	Pod/Brdlf	Southland	206.3	51.6	5.4	.	.	.	608.3
Z174	370	Other Shrub	Southland	0.0	0.0	1.0	.	.	.	0.0

Plots not used in the analysis

CMSID	Reason
DD78	Outside LCDB1 area
BJ107	Abandoned
AD140	Abandoned
AF162	Abandoned
AF174	Abandoned
AL167	Abandoned
AN130	Abandoned
AQ128	Abandoned
AR152	Abandoned
AS130	Abandoned
AS157	Abandoned
AS159	Abandoned
AT158	Abandoned
AW140	Abandoned
AX140	Abandoned
AY117	Abandoned
BB121	Abandoned
BD106	Abandoned
BF111	Abandoned
BG101	Abandoned
BG104	Abandoned
BG106	Abandoned
BG126	Abandoned
BG96	Abandoned
BH94	Abandoned
BJ107	Abandoned
BK116	Abandoned
BL100	Abandoned
BL116	Abandoned
BL92	Abandoned
BM6	Abandoned
BN6	Abandoned
BS19	Abandoned
BT116	Abandoned
BT20	Abandoned
BV16	Abandoned
BV21	Abandoned
BW108	Abandoned

CMSID	Reason
BW114	Abandoned
BX14	Abandoned
BX23	Abandoned
BY24	Abandoned
BY98	Abandoned
BZ109	Abandoned
CB25	Abandoned
CE31	Abandoned
CF36	Abandoned
CF76	Abandoned
CG101	Abandoned
CG25	Abandoned
CG33	Abandoned
CG77	Abandoned
CH74	Abandoned
CI64	Abandoned
CI66	Abandoned
CJ69	Abandoned
CJ70	Abandoned
CJ76	Abandoned
CJ78	Abandoned
CK65	Abandoned
CK70	Abandoned
CK71	Abandoned
CL101	Abandoned
CL52	Abandoned
CL77	Abandoned
CL98	Abandoned
CM72	Abandoned
CM78	Abandoned
CP47	Abandoned
CP69	Abandoned
CP81	Abandoned
CP96	Abandoned
CQ103	Abandoned
CS101	Abandoned
CT42	Abandoned
CT84	Abandoned
CU43	Abandoned
CU92	Abandoned
CU95	Abandoned
CW83	Abandoned
CX58	Abandoned
CX75	Abandoned
CX79	Abandoned
CX81	Abandoned
CZ70	Abandoned
CZ79	Abandoned
DA55	Abandoned
DB70	Abandoned

CMSID	Reason
DC59	Abandoned
DC71	Abandoned
DE67	Abandoned
DL59	Abandoned
DL66	Abandoned
DL67	Abandoned
DN57	Abandoned
DN59	Abandoned
DP71	Abandoned
DS62	Abandoned
DT54	Abandoned
DV56	Abandoned
H166	Abandoned
I156	Abandoned
I162	Abandoned
I163	Abandoned
J160	Abandoned
J161	Abandoned
J162	Abandoned
J165	Abandoned
L160	Abandoned
M161	Abandoned
N151	Abandoned
O185	Abandoned
P149	Abandoned
R156	Abandoned
R157	Abandoned
U167	Abandoned
Y178	Abandoned

Appendix 3. Species information including wood density and mean per hectare stem volume and carbon

Species	Plant type	Source	Conif/ Brdlf	Whole stem density (kg/m^3)	Density Source (Species, Genus, Type)	Stem Volume (m^3/ha)	AG Carbon (tC/ha)
Abies koreana E.H.Wilson	canopy tree	Adven	Conif	476	T	0.00	0.00
Acacia dealbata	canopy tree	Adven	Brdlv	379	S	0.01	0.00
Acacia mearnsii De Wild.	canopy tree	Adven	Brdlv	442	S	0.04	0.01
Acer platanoides L.	canopy tree	Adven	Brdlv	488	G	0.00	0.00
Acer pseudoplatanus	canopy tree	Adven	Brdlv	493	S	0.03	0.01
Ackama rosifolia	subcanopy tree	Indig	Brdlv	493	T	0.52	0.17
Agathis australis	canopy tree	Indig	Conif	435	S	0.95	0.25
Alectryon excelsus	subcanopy tree	Indig	Brdlv	493	T	0.06	0.02
Alseuosmia macrophylla	shrub	Indig	Brdlv	333	T	0.01	0.00
Archeria racemosa	shrub	Indig	Brdlv	333	T	0.03	0.01
Archeria traversii	shrub	Indig	Brdlv	333	T	0.35	0.14
Aristotelia fruticosa	shrub	Indig	Brdlv	333	T	0.00	0.00
Aristotelia serrata	subcanopy tree	Indig	Brdlv	493	T	0.35	0.13
Ascarina lucida	subcanopy tree	Indig	Brdlv	493	T	0.09	0.03
Beilschmiedia sp.	canopy tree	Indig	Brdlv	516	G	0.00	0.00
Beilschmiedia tarairi	canopy tree	Indig	Brdlv	527	S	0.63	0.22
Beilschmiedia tawa	canopy tree	Indig	Brdlv	505	S	17.82	5.62
Beilschmiedia tawaroa	canopy tree	Indig	Brdlv	516	G	0.00	0.00
Berberis glaucocarpa	shrub	Adven	Brdlv	333	T	0.01	0.00
Brachyglottis buchananii	shrub	Indig	Brdlv	333	T	0.03	0.01
Brachyglottis elaeagnifolia	shrub	Indig	Brdlv	333	T	0.00	0.00
Brachyglottis kirkii	shrub	Indig	Brdlv	333	T	0.00	0.00
Brachyglottis repanda	shrub	Indig	Brdlv	333	T	0.12	0.04
Brachyglottis rotundifolia	shrub	Indig	Brdlv	333	T	0.03	0.01
Buddleja davidii	shrub	Adven	Brdlv	333	T	0.03	0.01
Camellia japonica L.	shrub	Adven	Brdlv	333	T	0.00	0.00
Carmichaelia aligera	shrub	Indig	Brdlv	333	T	0.00	0.00
Carmichaelia australis	shrub	Indig	Brdlv	333	T	0.01	0.00
Carmichaelia grandiflora	shrub	Indig	Brdlv	333	T	0.00	0.00
Carpodetus serratus	subcanopy tree	Indig	Brdlv	493	T	1.67	0.62
Chamaecyparis lawsoniana	canopy tree	Adven	Conif	376	S	0.00	0.00
Clematis foetida	shrub	Indig	Brdlv	333	T	0.00	0.00
Clematis paniculata	shrub	Indig	Brdlv	333	T	0.00	0.00
Clematis parviflora	shrub	Indig	Brdlv	333	T	0.00	0.00
Clematis species	shrub	either	Brdlv	333	T	0.00	0.00
Coprosma ×cunninghamii	shrub	Indig	Brdlv	333	G	0.00	0.00
Coprosma arborea	shrub	Indig	Brdlv	333	G	0.19	0.06
Coprosma areolata	shrub	Indig	Brdlv	333	G	0.02	0.01
Coprosma cheesemanii	shrub	Indig	Brdlv	333	G	0.00	0.00
Coprosma ciliata	shrub	Indig	Brdlv	333	G	0.04	0.02

Species	Plant type	Source	Conif/ Brdlf	Whole stem density (kg/m^3)	Density Source (Species, Genus, Type)	Stem Volume (m^3/ha)	AG Carbon (tC/ha)
Coprosma colensoi	shrub	Indig	Brdlv	333	G	0.00	0.00
Coprosma colensoi × Taylorae	shrub	Indig	Brdlv	333	T	0.00	0.00
Coprosma crassifolia	shrub	Indig	Brdlv	333	G	0.00	0.00
Coprosma decurva	shrub	Indig	Brdlv	333	G	0.00	0.00
Coprosma foetidissima	shrub	Indig	Brdlv	333	G	0.24	0.08
Coprosma foetidissima × Taylorae	shrub	Indig	Brdlv	333	T	0.00	0.00
Coprosma grandifolia	shrub	Indig	Brdlv	333	S	0.24	0.08
Coprosma hybrid	shrub	Indig	Brdlv	333	G	0.00	0.00
Coprosma linariifolia	shrub	Indig	Brdlv	333	G	0.14	0.04
Coprosma lucida	shrub	Indig	Brdlv	333	G	0.06	0.02
Coprosma microcarpa	shrub	Indig	Brdlv	333	G	0.00	0.00
Coprosma parviflora	shrub	Indig	Brdlv	333	G	0.02	0.01
Coprosma perpusilla Colenso Subsp. Perpusilla	shrub	Indig	Brdlv	333	G	0.00	0.00
Coprosma propinqua	shrub	Indig	Brdlv	333	G	0.05	0.02
Coprosma propinqua × Robusta	shrub	Indig	Brdlv	333	T	0.00	0.00
Coprosma pseudociliata G.T.Jane	shrub	Indig	Brdlv	333	T	0.00	0.00
Coprosma pseudociliata X Tayloriae	shrub	Indig	Brdlv	333	T	0.00	0.00
Coprosma pseudocuneata	shrub	Indig	Brdlv	333	G	0.05	0.02
Coprosma ramulosa	shrub	Indig	Brdlv	333	G	0.00	0.00
Coprosma rhamnoides	shrub	Indig	Brdlv	333	G	0.00	0.00
Coprosma rigida	shrub	Indig	Brdlv	333	G	0.00	0.00
Coprosma robusta	shrub	Indig	Brdlv	333	T	0.06	0.02
Coprosma rotundifolia	shrub	Indig	Brdlv	333	G	0.02	0.01
Coprosma rubra	shrub	Indig	Brdlv	333	G	0.00	0.00
Coprosma rugosa	shrub	Indig	Brdlv	333	G	0.01	0.00
Coprosma small-leaved	shrub	Indig	Brdlv	333	T	0.00	0.00
Coprosma sp. (T)	shrub	Indig	Brdlv	333	G	0.02	0.01
Coprosma species	shrub	Indig	Brdlv	333	G	0.00	0.00
Coprosma tayloriae A.P.Druce	shrub	Indig	Brdlv	333	G	0.03	0.01
Coprosma tayloriae Hybrid	shrub	Indig	Brdlv	333	T	0.00	0.00
Coprosma tenuicaulis	shrub	Indig	Brdlv	333	G	0.00	0.00
Coprosma tenuifolia	shrub	Indig	Brdlv	333	G	0.02	0.01
Cordyline australis	t-fern	Indig	Brdlv	197	T	0.14	0.03
Cordyline banksii	t-fern	Indig	Brdlv	197	T	0.00	0.00
Cordyline indivisa	t-fern	Indig	Brdlv	197	T	0.01	0.00
Coriaria arborea	shrub	Indig	Brdlv	333	T	0.14	0.05
Corokia buddleioides	shrub	Indig	Brdlv	333	T	0.00	0.00
Corokia cotoneaster	shrub	Indig	Brdlv	333	T	0.00	0.00

Species	Plant type	Source	Conif/ Brdlf	Whole stem density (kg/m^3)	Density Source (Species, Genus, Type)	Stem Volume (m^3/ha)	AG Carbon (tC/ha)
Corynocarpus laevigatus	canopy tree	Indig	Brdlv	476	T	0.01	0.01
Crataegus monogyna	subcanopy tree	Adven	Brdlv	493	T	0.00	0.00
Cryptomeria japonica	canopy tree	Adven	Conif	288	S	0.00	0.00
Cupressus macrocarpa	canopy tree	Adven	Conif	370	S	0.00	0.00
Cyathea cunninghamii	t-fern	Indig	fern	197	T	0.24	0.01
Cyathea dealbata	t-fern	Indig	fern	197	T	3.74	0.22
Cyathea medullaris	t-fern	Indig	fern	197	T	1.98	0.12
Cyathea smithii	t-fern	Indig	fern	197	T	6.55	0.38
Cyathea species	t-fern	Indig	fern	197	T	0.00	0.00
Cyathodes juniperina	shrub	Indig	Brdlv	333	T	0.01	0.00
Cytisus scoparius	shrub	Adven	Brdlv	333	T	0.01	0.00
Dacrycarpus dacrydioides	canopy tree	Indig	Conif	351	S	3.44	0.75
Dacrydium cupressinum	canopy tree	Indig	Conif	433	S	19.94	5.31
Dicksonia fibrosa	t-fern	Indig	fern	197	T	0.18	0.01
Dicksonia lanata	t-fern	Indig	fern	197	T	0.00	0.00
Dicksonia species	t-fern	Indig	fern	197	T	0.00	0.00
Dicksonia squarrosa	t-fern	Indig	fern	197	T	4.69	0.27
Discaria toumatou	shrub	Indig	Brdlv	333	T	0.02	0.01
Dracophyllum filifolium	shrub	Indig	Brdlv	333	T	0.00	0.00
Dracophyllum fiordense	shrub	Indig	Brdlv	333	T	0.00	0.00
Dracophyllum latifolium	shrub	Indig	Brdlv	333	T	0.04	0.01
Dracophyllum longifolium	shrub	Indig	Brdlv	333	T	0.25	0.09
Dracophyllum species	shrub	Indig	Brdlv	333	T	0.01	0.00
Dracophyllum subulatum	shrub	Indig	Brdlv	333	T	0.00	0.00
Dracophyllum townsonii	shrub	Indig	Brdlv	333	T	0.01	0.00
Dracophyllum traversii	shrub	Indig	Brdlv	333	T	0.37	0.12
Dysoxylum spectabile	canopy tree	Indig	Brdlv	424	S	1.06	0.33
Elaeocarpus dentatus	canopy tree	Indig	Brdlv	526	S	2.72	0.92
Elaeocarpus dentatus var. obovatus	subcanopy tree	Indig	Brdlv	487	G	0.00	0.00
Elaeocarpus hookerianus	subcanopy tree	Indig	Brdlv	448	S	0.71	0.22
Erica lusitanica	shrub	Adven	Brdlv	333	T	0.00	0.00
Eucalyptus species	canopy tree	Adven	Brdlv	477	G	0.00	0.00
Eucalyptus viminalis Labill.	canopy tree	Adven	Brdlv	477	G	0.11	0.03
Fraxinus excelsior	canopy tree	Adven	Brdlv	508	G	0.00	0.00
Freycinetia banksii	shrub	Indig	Brdlv	333	T	0.07	0.02
Freycinetia baueriana	shrub	Indig	Brdlv	333	T	0.00	0.00
Fuchsia excorticata	subcanopy tree	Indig	Brdlv	493	T	0.50	0.19
Gaultheria antipoda	shrub	Indig	Brdlv	333	T	0.00	0.00
Gaultheria crassa	shrub	Indig	Brdlv	333	T	0.00	0.00
Gaultheria paniculata	shrub	Indig	Brdlv	333	T	0.00	0.00
Gaultheria rupestris	shrub	Indig	Brdlv	333	T	0.00	0.00
Geniostoma ligustrifolium	shrub	Indig	Brdlv	333	T	0.07	0.02
Geniostoma rupestre	shrub	Indig	Brdlv	333	T	0.04	0.01
Griselinia littoralis	subcanopy tree	Indig	Brdlv	493	T	4.53	1.75

Species	Plant type	Source	Conif/ Brdlf	Whole stem density (kg/m^3)	Density Source (Species, Genus, Type)	Stem Volume (m^3/ha)	AG Carbon (tC/ha)
Griselinia lucida	subcanopy tree	Indig	Brdlv	493	T	0.03	0.01
Hakea saligna	shrub	Adven	Brdlv	333	T	0.02	0.01
Hakea sericea	shrub	Adven	Brdlv	333	T	0.05	0.02
Halocarpus bidwillii	canopy tree	Indig	Conif	476	T	0.02	0.01
Halocarpus biformis	canopy tree	Indig	Conif	476	T	0.49	0.20
Hebe corriganii	shrub	Indig	Brdlv	333	T	0.00	0.00
Hebe parviflora	shrub	Indig	Brdlv	333	T	0.01	0.00
Hebe salicifolia	shrub	Indig	Brdlv	333	T	0.01	0.00
Hebe species	shrub	Indig	Brdlv	333	T	0.00	0.00
Hebe stricta	shrub	Indig	Brdlv	333	T	0.02	0.01
Hebe subalpina	shrub	Indig	Brdlv	333	T	0.00	0.00
Hedycarya arborea	subcanopy tree	Indig	Brdlv	465	S	2.00	0.70
Hoheria glabrata	subcanopy tree	Indig	Brdlv	493	T	0.22	0.08
Hoheria lyallii	subcanopy tree	Indig	Brdlv	493	T	0.05	0.02
Hoheria populnea A.Cunn.	subcanopy tree	Indig	Brdlv	493	T	0.03	0.01
Hoheria sexstylosa	subcanopy tree	Indig	Brdlv	493	T	0.00	0.00
Hoheria sexstylosa Var. Ovata (G.Simpson & J.S.Thomson) Allan	subcanopy tree	Indig	Brdlv	493	T	0.00	0.00
Ixerba brexioides	subcanopy tree	Indig	Brdlv	493	T	2.81	0.99
Knightia excelsa	canopy tree	Indig	Brdlv	503	S	3.64	1.17
Kunzea ericoides	subcanopy tree	Indig	Brdlv	635	S	5.21	2.19
Lagarostrobos colensoi (Hook.) Quinn	subcanopy tree	Indig	Conif	499	S	0.03	0.01
Larix decidua	canopy tree	Adven	Conif	395	S	0.01	0.00
Laurelia novae-zelandiae	canopy tree	Indig	Brdlv	341	S	1.15	0.27
Leionema nudum (Hook.) Paul G.Wilson	shrub	Indig	Brdlv	333	T	0.00	0.00
Lepidothamnus intermedius	subcanopy tree	Indig	Conif	641	S	0.98	0.47
Leptecophylla juniperina (J.R.Forst. & G.Forst.) C.M.Weiller	shrub	Indig	Brdlv	333	T	0.00	0.00
Leptospermum scoparium	Shrub	Indig	Brdlv	614	S	2.00	0.91
Leucopogon colensoi	shrub	Indig	Brdlv	333	T	0.00	0.00
Leucopogon fasciculatus	shrub	Indig	Brdlv	333	T	0.15	0.05
Leycesteria formosa	shrub	Adven	Brdlv	333	T	0.00	0.00
Libocedrus bidwillii	canopy tree	Indig	Conif	329	S	0.80	0.21
Litsea calicaris	subcanopy tree	Indig	Brdlv	454	S	0.18	0.05
Lonicera japonica	shrub	Adven	Brdlv	333	T	0.00	0.00
Lophomyrtus bullata	shrub	Indig	Brdlv	333	T	0.00	0.00
Lophomyrtus obcordata	shrub	Indig	Brdlv	333	T	0.00	0.00
Lupinus arboreus	shrub	Adven	Brdlv	333	T	0.00	0.00
Macropiper excelsum	shrub	Indig	Brdlv	333	T	0.01	0.01
Manoao colensoi	canopy tree	Indig	Conif	476	T	0.23	0.08
Melicope simplex	shrub	Indig	Brdlv	333	T	0.00	0.00

Species	Plant type	Source	Conif/ Brdlf	Whole stem density (kg/m³)	Density Source (Species, Genus, Type)	Stem Volume (m³/ha)	AG Carbon (tC/ha)
Melicytus alpinus	shrub	Indig	Brdlv	333	T	0.00	0.00
Melicytus lanceolatus	shrub	Indig	Brdlv	333	T	0.00	0.00
Melicytus macrophyllus	shrub	Indig	Brdlv	333	T	0.07	0.02
Melicytus ramiflorus	subcanopy tree	Indig	Brdlv	358	S	4.85	1.45
Melicytus species	shrub	Indig	Brdlv	333	T	0.00	0.00
Meryta sinclairii (Hook.F.) Seem.	subcanopy tree	Indig	Brdlv	493	T	0.01	0.00
Metrosideros albiflora	shrub	Indig	Brdlv	333	T	0.00	0.00
Metrosideros colensoi	shrub	Indig	Brdlv	333	T	0.00	0.00
Metrosideros diffusa	shrub	Indig	Brdlv	333	T	0.03	0.01
Metrosideros excelsa	canopy tree	Indig	Brdlv	476	T	0.08	0.03
Metrosideros fulgens	shrub	Indig	Brdlv	333	T	0.09	0.03
Metrosideros parkinsonii	shrub	Indig	Brdlv	333	T	0.02	0.01
Metrosideros perforata	shrub	Indig	Brdlv	333	T	0.02	0.01
Metrosideros robusta	canopy tree	Indig	Brdlv	632	S	3.50	1.29
Metrosideros species	canopy tree	Indig	Brdlv	476	T	0.01	0.01
Metrosideros umbellata	canopy tree	Indig	Brdlv	746	S	12.26	5.68
Mida salicifolia	subcanopy tree	Indig	Brdlv	493	T	0.09	0.03
Muehlenbeckia australis	shrub	Indig	Brdlv	333	T	0.00	0.00
Muehlenbeckia species	shrub	Indig	Brdlv	333	T	0.00	0.00
Myoporum laetum	shrub	Indig	Brdlv	333	T	0.00	0.00
Myrsine australis	subcanopy tree	Indig	Brdlv	493	T	0.40	0.15
Myrsine divaricata	shrub	Indig	Brdlv	333	T	0.23	0.08
Myrsine salicina	subcanopy tree	Indig	Brdlv	493	T	0.97	0.33
Neomyrtus pedunculata	shrub	Indig	Brdlv	333	T	0.10	0.03
Nestegis cunninghamii	subcanopy tree	Indig	Brdlv	770	S	0.21	0.10
Nestegis lanceolata	subcanopy tree	Indig	Brdlv	493	T	0.23	0.08
Nestegis montana	subcanopy tree	Indig	Brdlv	493	T	0.01	0.00
Nothofagus fusca	canopy tree	Indig	Brdlv	448	S	58.63	16.33
Nothofagus fusca x menziesii	canopy tree	Indig	Brdlv	476	T	0.05	0.01
Nothofagus menziesii	canopy tree	Indig	Brdlv	445	S	72.42	21.15
Nothofagus solandri	canopy tree	Indig	Brdlv	536	S	8.70	2.86
Nothofagus solandri Var. Cliffortioides	canopy tree	Indig	Brdlv	475	S	28.50	9.12
Nothofagus solandri Var. Cliffortioides × Fusca	canopy tree	Indig	Brdlv	476	T	0.01	0.00
Nothofagus species	canopy tree	Indig	Brdlv	468	S	0.20	0.07
Nothofagus truncata	canopy tree	Indig	Brdlv	525	S	11.88	3.79
Notospartium carmichaeliae	shrub	Indig	Brdlv	333	T	0.00	0.00
Olearia albida	subcanopy tree	Indig	Brdlv	493	T	0.00	0.00
Olearia arborescens	shrub	Indig	Brdlv	333	T	0.01	0.00
Olearia avicenniifolia	shrub	Indig	Brdlv	333	T	0.02	0.01
Olearia colensoi	shrub	Indig	Brdlv	333	T	0.46	0.18
Olearia furfuracea	shrub	Indig	Brdlv	333	T	0.00	0.00
Olearia ilicifolia	shrub	Indig	Brdlv	333	T	0.08	0.03

Species	Plant type	Source	Conif/ Brdlf	Whole stem density (kg/m^3)	Density Source (Species, Genus, Type)	Stem Volume (m^3/ha)	AG Carbon (tC/ha)
Olearia lacunosa	shrub	Indig	Brdlv	333	T	0.06	0.02
Olearia lineata	shrub	Indig	Brdlv	333	T	0.00	0.00
Olearia nummulariifolia	shrub	Indig	Brdlv	333	T	0.00	0.00
Olearia oporina	shrub	Indig	Brdlv	333	T	0.09	0.04
Olearia paniculata	shrub	Indig	Brdlv	333	T	0.01	0.00
Olearia rani	shrub	Indig	Brdlv	333	T	0.56	0.17
Olearia species	shrub	Indig	Brdlv	333	T	0.00	0.00
Olearia townsonii	shrub	Indig	Brdlv	333	T	0.00	0.00
Olearia virgata	shrub	Indig	Brdlv	333	T	0.00	0.00
Ozothamnus leptophyllus	shrub	Indig	Brdlv	333	T	0.00	0.00
Parsonsia heterophylla	shrub	Indig	Brdlv	333	T	0.00	0.00
Parsonsia species	shrub	Indig	Brdlv	333	T	0.00	0.00
Passiflora tetrandra	shrub	Indig	Brdlv	333	T	0.01	0.00
Pennantia corymbosa	shrub	Indig	Brdlv	333	T	0.14	0.04
Phebalium nudum	shrub	Indig	Brdlv	333	T	0.00	0.00
Phyllocladus alpinus	canopy tree	Indig	Conif	476	T	0.68	0.25
Phyllocladus glaucus	canopy tree	Indig	Conif	476	T	0.12	0.04
Phyllocladus toatoa Molloy	canopy tree	Indig	Conif	476	T	0.19	0.06
Phyllocladus trichomanoides	canopy tree	Indig	Conif	489	S	0.65	0.20
Pinus contorta	canopy tree	Adven	Conif	375	S	0.00	0.00
Pinus pinaster	canopy tree	Adven	Conif	401	S	0.24	0.06
Pinus radiata	canopy tree	Adven	Conif	420	S	0.50	0.13
Pinus species	canopy tree	Adven	Conif	476	T	0.00	0.00
Pittosporum colensoi	subcanopy tree	Indig	Brdlv	493	T	0.02	0.01
Pittosporum crassicaule	shrub	Indig	Brdlv	333	T	0.00	0.00
Pittosporum divaricatum	shrub	Indig	Brdlv	333	T	0.00	0.00
Pittosporum eugenioides	subcanopy tree	Indig	Brdlv	493	T	0.18	0.06
Pittosporum lineare	shrub	Indig	Brdlv	333	T	0.00	0.00
Pittosporum rigidum	shrub	Indig	Brdlv	333	T	0.00	0.00
Pittosporum species	shrub	Indig	Brdlv	333	T	0.00	0.00
Pittosporum tenuifolium	subcanopy tree	Indig	Brdlv	493	T	0.16	0.06
Pittosporum umbellatum	subcanopy tree	Indig	Brdlv	493	T	0.00	0.00
Pittosporum virgatum	shrub	Indig	Brdlv	333	T	0.00	0.00
Plagianthus regius	canopy tree	Indig	Brdlv	476	T	0.01	0.00
Podocarpus acutifolius	canopy tree	Indig	Conif	476	T	0.01	0.00
Podocarpus hallii	canopy tree	Indig	Conif	476	T	4.18	1.36
Podocarpus nivalis	shrub	Indig	Conif	333	T	0.00	0.00
Podocarpus species	canopy tree	Indig	Conif	476	T	0.00	0.00
Podocarpus totara	canopy tree	Indig	Conif	370	S	0.94	0.25
Populus lombardii	canopy tree	Adven	Brdlv	476	T	0.10	0.03
Populus species	canopy tree	Adven	Brdlv	476	T	0.00	0.00
Prumnopitys ferruginea	canopy tree	Indig	Conif	482	S	6.40	1.92
Prumnopitys taxifolia	canopy tree	Indig	Conif	499	S	2.72	0.81
Prunus laurocerasus	subcanopy tree	Adven	Brdlv	493	T	0.00	0.00

Species	Plant type	Source	Conif/ Brdlf	Whole stem density (kg/m^3)	Density Source (Species, Genus, Type)	Stem Volume (m^3/ha)	AG Carbon (tC/ha)
Prunus species	subcanopy tree	Adven	Brdlv	493	T	0.00	0.00
Pseudopanax arboreus	subcanopy tree	Indig	Brdlv	493	T	0.38	0.15
Pseudopanax colensoi	subcanopy tree	Indig	Brdlv	493	T	0.09	0.04
Pseudopanax crassifolius	subcanopy tree	Indig	Brdlv	493	T	0.60	0.22
Pseudopanax discolor	subcanopy tree	Indig	Brdlv	493	T	0.01	0.00
Pseudopanax ferox	subcanopy tree	Indig	Brdlv	493	T	0.00	0.00
Pseudopanax laetus	subcanopy tree	Indig	Brdlv	493	T	0.00	0.00
Pseudopanax lessonii	subcanopy tree	Indig	Brdlv	493	T	0.00	0.00
Pseudopanax linearis	subcanopy tree	Indig	Brdlv	493	T	0.04	0.02
Pseudopanax species	shrub	Indig	Brdlv	333	T	0.00	0.00
Pseudotsuga menziesii	canopy tree	Adven	Conif	411	S	0.00	0.00
Pseudowintera axillaris	subcanopy tree	Indig	Brdlv	493	T	0.14	0.06
Pseudowintera colorata	subcanopy tree	Indig	Brdlv	389	S	0.99	0.37
Quintinia acutifolia	subcanopy tree	Indig	Brdlv	493	T	3.37	1.09
Quintinia serrata	subcanopy tree	Indig	Brdlv	427	S	1.64	0.51
Raukaua anomalus (Hook.) A.D.Mitch., Frodin & Heads	subcanopy tree	Indig	Brdlv	493	T	0.00	0.00
Raukaua edgerleyi	subcanopy tree	Indig	Brdlv	493	T	0.05	0.02
Raukaua simplex	subcanopy tree	Indig	Brdlv	493	T	0.41	0.17
Rhopalostylis sapida	t-fern	Indig	palm	197	T	0.44	0.13
Ripogonum scandens	shrub	Indig	Brdlv	333	T	0.00	0.00
Rosa rubiginosa	shrub	Adven	Brdlv	333	T	0.00	0.00
Rubus australis	shrub	Indig	Brdlv	333	T	0.00	0.00
Rubus cissoides	shrub	Indig	Brdlv	333	T	0.04	0.01
Rubus schmidelioides	shrub	Indig	Brdlv	333	T	0.00	0.00
Rubus species	shrub	either	Brdlv	333	T	0.00	0.00
Salix cinerea	canopy tree	Adven	Brdlv	476	T	0.01	0.01
Salix fragilis	canopy tree	Adven	Brdlv	330	S	0.08	0.02
Salix species	canopy tree	Adven	Brdlv	476	T	0.00	0.00
Sambucus nigra	subcanopy tree	Adven	Brdlv	493	T	0.00	0.00
Schefflera digitata	subcanopy tree	Indig	Brdlv	493	T	0.23	0.09
Solanum mauritianum	shrub	Adven	Brdlv	333	T	0.01	0.00
Sophora chathamica Cockayne	shrub	Indig	Brdlv	333	T	0.01	0.00
Sophora microphylla	subcanopy tree	Indig	Brdlv	493	T	0.06	0.02
Sophora species	subcanopy tree	Indig	Brdlv	493	T	0.00	0.00
Sophora tetraptera	subcanopy tree	Indig	Brdlv	493	T	0.04	0.01
Streblus heterophyllus	subcanopy tree	Indig	Brdlv	493	T	0.00	0.00
Toronia toru	shrub	Indig	Brdlv	333	T	0.03	0.01
Tree fern	t-fern	Indig	fern	197	T	0.00	0.00
Ulex europaeus	shrub	Adven	Brdlv	333	T	0.18	0.06
Ulmus glabra Mill.	canopy tree	Adven	Brdlv	476	T	0.00	0.00
Unknown species	shrub	either	either	333	U	1.08	0.36
Urtica ferox	shrub	Indig	Brdlv	333	T	0.00	0.00
Vitex lucens	canopy tree	Indig	Brdlv	476	T	0.37	0.12

Species	Plant type	Source	Conif/ Brdlf	Whole stem density (kg/m^3)	Density Source (Species, Genus, Type)	Stem Volume (m^3/ha)	AG Carbon (tC/ha)
Weinmannia racemosa	canopy tree	Indig	Brdlv	469	S	41.70	13.46
Weinmannia silvicola	canopy tree	Indig	Brdlv	476	T	1.49	0.48

Appendix 4. AGB and CWD carbon at NVS and LUCAS measurements for each NVS plot

CMSID	NVS year	LUCAS year	NVS AGB (tC/ha)	NVS CWD (tC/ha)	LUCAS AGB (tC/ha)	LUCAS CWD (tC/ha)
AB143	1977	2005	152.6	12.9	133.9	47.8
AC141	1977	2005	296.4	15.1	320.9	9.2
AC160	1977	2005	232.9	24.1	257.5	15.5
AC161	1977	2003	203.6	12.5	232.0	7.3
AD141	1977	2003	151.1	32.6	172.4	18.2
AD142	1977	2002	161.2	45.0	175.9	25.7
AE141	1977	2003	229.4	47.6	248.3	29.3
AE142	1977	2003	85.5	53.9	102.8	29.7
AF166	1983	2003	84.9	0.0	152.1	2.6
AF167	1983	2004	69.0	2.4	96.7	2.4
AG144	1979	2005	198.0	-25.4	162.6	24.0
AG145	1979	2005	68.0	1.4	77.4	7.1
AG166	1983	2003	154.1	5.9	175.9	3.7
AJ133	1991	2005	269.3	117.9	155.2	163.9
AJ134	1991	2005	352.5	52.1	360.5	38.3
AK134	1991	2005	270.5	53.2	285.2	42.7
AK138	1985	2003	49.7	-12.2	7.2	20.2
AO127	1998	2001	40.1	20.6	41.8	20.2
AP128	1998	2005	56.8	25.2	60.0	21.8
AS128	1998	2004	123.2	1.8	131.5	2.6
AU125	1998	2005	185.7	21.7	184.9	20.7
AW122	1998	2005	486.9	39.1	473.4	33.7
AW123	1979	2004	70.9	0.6	85.3	3.7
AW124	1994	2004	174.6	30.0	152.2	50.8
AX124	1995	2004	79.3	127.1	84.5	106.2
AY112	1988	2005	262.1	12.5	283.4	12.9
AZ133	1978	2004	53.1	3.5	81.0	8.0
BA122	1992	2003	211.3	3.4	227.0	2.6
BA125	1983	2005	84.4	4.1	99.7	3.6
BA132	1978	2003	200.0	-4.8	213.1	2.9
BB124	1983	2005	69.1	12.1	67.7	22.5
BC130	1976	2004	58.3	-34.5	59.4	6.7
BD121	1974	2004	223.5	11.1	268.4	7.6
BE110	1975	2004	132.9	-11.9	136.1	18.6
BF120	1974	2003	220.0	52.9	284.0	29.7
BF121	1986	2003	141.5	-3.4	138.8	12.9
BF127	1998	2003	95.4	11.4	92.8	14.6
BF128	1985	2004	89.6	-17.7	58.6	28.3
BG118	1975	2005	114.8	23.1	134.6	14.2
BG121	1986	2003	116.3	46.4	126.6	41.1
BG123	1986	2002	133.4	3.6	137.1	9.3
BG125	1984	2003	130.0	1.0	133.2	5.0
BH120	1986	2003	462.7	7.7	258.8	130.7
BH121	1986	2003	63.4	9.8	79.3	11.0

CMSID	NVS year	LUCAS year	NVS AGB (tC/ha)	NVS CWD (tC/ha)	LUCAS AGB (tC/ha)	LUCAS CWD (tC/ha)
BH127	1986	2003	40.8	23.5	54.9	19.8
BI104	1982	2004	128.0	42.1	125.0	37.1
BI105	1982	2004	220.8	31.1	269.2	19.5
BI106	1982	2004	234.7	-12.0	240.3	26.1
BI116	1980	2002	162.5	7.1	183.6	15.8
BI117	1980	2003	79.1	11.6	93.0	11.2
BI118	1980	2004	248.3	43.2	299.4	26.8
BI127	1986	2004	28.6	23.5	30.8	25.3
BI97	1985	2005	282.5	14.7	225.2	42.9
BI99	1985	2003	217.2	108.8	283.6	74.8
BJ98	1985	2004	300.4	39.2	342.4	26.0
BJ99	1985	2003	239.5	26.9	309.9	19.2
BK102	1982	2003	95.1	5.3	101.9	5.2
BK103	1982	2004	163.0	33.7	201.5	20.8
BK105	1999	2001	132.6	48.0	134.3	45.8
BK118	1980	2005	86.9	-4.6	56.4	19.9
BK120	1986	2003	76.0	14.6	81.7	20.3
BK126	1986	2001	63.4	14.0	47.9	25.3
BK98	1986	2005	146.1	-10.5	158.6	11.7
BK99	1985	2002	246.3	68.5	292.9	56.1
BL99	1986	2003	89.2	-0.3	99.2	1.7
BM100	1981	2002	68.1	133.6	71.9	88.6
BM99	1981	2005	158.4	21.1	163.5	25.1
BN109	1982	2001	170.1	-8.0	144.7	20.0
BO109	1982	2001	119.2	8.1	121.9	14.9
BO110	1982	2002	98.7	7.6	104.6	8.3
BS103	1983	2003	289.1	8.8	326.4	8.8
BS104	1983	2005	178.5	13.7	178.7	27.4
BT102	1983	2004	261.8	32.5	287.9	21.2
BU100	1983	2005	161.9	16.9	188.8	10.9
BU101	1983	2005	415.4	20.9	524.9	13.6
BU102	1983	2004	202.6	0.9	219.1	0.8
BU103	1984	2002	162.5	50.5	189.7	36.1
BV103	1984	2004	254.3	50.4	320.2	32.5
BW102	1984	2002	229.8	41.9	225.5	61.6
BX112	1981	2003	211.4	2.0	230.9	1.7
BX114	1982	2003	177.5	-7.9	221.6	1.1
BZ73	1985	2003	148.6	-68.7	18.2	33.0
CL55	1986	2003	181.7	7.6	165.3	36.2
CL96	1984	2002	212.6	9.0	221.1	11.9
CM104	1985	2002	67.0	11.8	90.6	8.0
CM55	1986	2005	83.3	18.0	129.5	11.7
CM56	1986	2002	57.5	39.6	30.6	49.6
CM97	1984	2002	173.3	-1.3	159.7	12.9
CN102	1985	2004	49.7	9.4	63.5	6.3
CN103	1985	2004	243.9	8.7	294.2	6.6
CN95	1984	2002	172.3	16.6	182.4	11.0

Appendix 4 cont.

CMSID	NVS year	LUCAS year	NVS AGB (tC/ha)	NVS CWD (tC/ha)	LUCAS AGB (tC/ha)	LUCAS CWD (tC/ha)
CN97	1984	2002	257.3	17.3	255.1	15.5
CN98	1984	2003	99.3	32.3	136.1	23.0
CO95	1984	2004	205.4	-5.1	155.2	42.8
CO97	1984	2004	110.5	26.4	126.0	18.0
CP92	1984	2004	119.8	3.5	139.0	6.3
CP94	1984	2004	271.4	16.5	342.7	26.9
CP95	1984	2005	225.0	1.2	237.9	12.8
CQ60	1992	2005	73.0	21.3	74.9	17.9
CQ61	1992	2003	47.3	-0.6	39.9	3.3
CQ65	1986	2002	169.2	5.5	124.1	35.9
CR61	2000	2003	102.4	0.3	109.1	0.3
CR62	1992	2003	157.5	33.1	164.3	28.3
CS72	1985	2003	190.2	2.8	185.8	20.7
CU51	1984	2001	111.5	-6.6	106.7	11.0
CV73	1981	2005	78.4	-3.4	90.1	8.7
CW79	1983	2005	38.3	52.5	59.1	33.4
CW81	1983	2001	102.4	-21.8	87.0	18.5
CX69	1978	2001	87.7	48.9	107.6	28.8
CX78	1983	2005	167.3	5.1	147.0	25.5
CY54	1994	2001	118.2	-4.1	111.2	6.2
CY71	1981	2003	143.4	59.7	181.6	37.0
CY72	1981	2001	158.9	-40.9	45.2	42.6
CY75	1981	2005	29.2	-1.1	56.6	0.8
CY78	1983	2003	46.8	-2.0	49.4	0.0
CZ74	1994	2003	103.5	15.5	109.2	12.6
DA57	1992	2003	96.9	317.2	106.2	247.1
DA58	1988	2003	130.2	-0.8	116.1	23.4
DB58	1992	2003	101.7	12.0	108.3	21.7
DD68	1981	2001	171.4	-46.2	83.9	27.1
DD70	1981	2004	304.0	25.4	346.3	15.1
DG62	1985	2003	195.9	-7.8	193.6	19.2
DG63	1985	2001	276.6	42.0	295.9	32.0
DO58	1982	2006	101.3	2.4	106.2	9.1
DP55	1983	2004	91.0	25.1	138.5	19.5
DP56	1982	2002	251.1	-45.8	114.4	58.3
H159	1987	2005	146.8	7.6	159.5	8.3
H167	1976	2003	71.6	0.4	88.9	4.1
H168	1976	2001	583.6	60.7	484.5	42.1
H170	1976	2003	340.8	-20.8	311.6	17.6
I167	1976	2003	121.2	7.3	146.8	5.4
J170	1978	2005	190.3	-5.6	196.4	3.5
J171	1996	2002	112.3	17.9	102.8	22.0
K156	1980	2001	144.2	6.3	150.2	4.4
K166	1981	2002	325.4	22.2	273.8	56.7
K171	1978	2004	244.7	-5.1	280.8	8.8
L157	1975	2004	100.9	31.3	128.5	16.3
L163	1981	2004	60.2	2.9	65.4	3.8

CMSID	NVS year	LUCAS year	NVS AGB (tC/ha)	NVS CWD (tC/ha)	LUCAS AGB (tC/ha)	LUCAS CWD (tC/ha)
L164	1981	2005	202.3	34.3	147.1	63.6
L169	1981	2003	118.0	50.0	134.1	46.9
L170	1978	2005	207.8	8.3	239.5	12.6
L171	1978	2003	118.0	1.7	130.4	5.0
M162	1981	2005	89.7	4.9	109.2	8.7
M163	1981	2004	370.8	16.6	249.6	85.8
M170	1978	2005	95.7	6.1	104.1	5.1
M171	1978	2005	92.2	2.1	128.9	4.9
N155	1984	2001	266.0	30.5	262.4	26.6
N156	1984	2005	208.7	30.4	92.4	90.8
N157	1975	2005	91.7	56.2	141.6	31.4
N158	1975	2004	341.9	94.3	369.4	49.3
O150	1975	2004	84.9	-2.2	88.4	4.8
O155	1977	2003	151.7	24.0	172.6	14.0
P155	1977	2003	220.2	16.3	244.7	10.9
P156	1977	2003	217.3	8.6	173.7	55.3
P158	1975	2001	86.0	79.0	91.2	72.9
P169	1983	2003	61.1	47.3	189.9	30.6
Q147	1983	2005	364.9	5.6	369.9	12.5
Q153	1975	2003	155.5	16.1	191.8	8.5
R171	1977	2003	396.0	20.4	393.8	19.1
U153	1989	2004	242.4	7.7	244.4	19.4
U181	1998	2002	170.6	7.2	173.8	6.8
V147	1977	2003	122.6	18.9	93.2	34.5
V182	1984	2003	107.6	5.5	124.7	3.6
W147	1977	2003	118.2	21.3	147.8	13.3
X143	1997	2004	33.5	19.3	34.4	16.9
Y143	1997	2002	304.6	25.4	301.7	22.8

Appendix 5. CWD decay class modifiers

Species	Decay class	Decay modifier
Unknown	0	1
Unknown	1	0.82
Unknown	2	0.66
Unknown	3	0.47
Nothofagus solandri Var. *Cliffortioides*	0	1
Nothofagus solandri Var. *Cliffortioides*	1	0.79
Nothofagus solandri Var. *Cliffortioides*	2	0.58
Nothofagus solandri Var. *Cliffortioides*	3	0.45
Nothofagus fusca	0	1
Nothofagus fusca	1	0.73
Nothofagus fusca	2	0.61
Nothofagus fusca	3	0.33
Weinmannia racemosa	0	1
Weinmannia racemosa	1	0.92
Weinmannia racemosa	2	0.82
Weinmannia racemosa	3	0.47
Metrosideros umbellata	0	1
Metrosideros umbellata	1	0.75
Metrosideros umbellata	2	0.64
Metrosideros umbellata	3	0.62