



Australian Government

Department of the Environment

National Inventory Report 2013

Volume 3

The Australian Government Submission to the United Nations
Framework Convention on Climate Change

Australian National Greenhouse Accounts



May 2015

© Commonwealth of Australia, 2015.



National Inventory Report 2013 Volume 3 is licensed by the Commonwealth of Australia for use under a Creative Commons By Attribution 3.0 Australia licence with the exception of the Coat of Arms of the Commonwealth of Australia, the logo of the agency responsible for publishing the report, content supplied by third parties, and any images depicting people. For licence conditions see: <http://creativecommons.org/licenses/by/3.0/au/>

This report should be attributed as '*National Inventory Report 2013 Volume 3*, Commonwealth of Australia 2015'.

The Commonwealth of Australia has made all reasonable efforts to identify content supplied by third parties using the following format '© Copyright, [name of third party]'.

Disclaimer

The views and opinions expressed in this publication are those of the authors and do not necessarily reflect those of the Australian Government or the Minister for the Environment.

Table of Contents

11. KYOTO Protocol LULUCF	2
11.1 General Information	2
11.2 Land-Related Information	3
11.3 Methods for carbon stock changes and greenhouse gas emissions and removal estimates	7
11.4 Deforestation	8
11.5 Afforestation & Reforestation	11
11.6 Article 3.4 activities – Forest management	18
11.7 Cropland management	51
11.8 Grazing land management	55
11.9 Revegetation	59
11.10 Other Information	59
12. Information on Accounting of Kyoto Units	60
12.1 Summary of information reported in the Standard Electronic Format Tables	60
12.2 Discrepancies and notifications	76
12.3 Publically Accessible Information	76
12.4 Calculation of the Commitment Period Reserve	76
12.5 KP-LULUCF Accounting	77
13. Changes to the National System	80
14. Changes to the National Registry	81
15. Minimization of Adverse Impacts in Accordance with Article 3.14	83
ANNEX 1: Key category Analysis	85
A1.1 Convention Accounting	85
A1.2 Kyoto Protocol LULUCF Activities	85
ANNEX 2: Uncertainty Analysis	105
A2.1 Energy	113
A2.2 Industrial Processes	116
A2.3 Agriculture	118
A2.4 Land Use, Land Use Change and Forestry	118
A2.5 Waste	119
ANNEX 3: Other Detailed Methodological Descriptions	122
ANNEX 4: Carbon Dioxide Reference Approach for the Energy Sector	123
A4.1 Estimation of CO ₂ Using the IPCC Reference Approach	123
A4.2 Comparison of Australian Methodology with IPCC Reference Approach	123
ANNEX 5: Assessment of Completeness	124
A5.1 Completeness of Activity Data	124
A5.2 Omitted Emission Sources	124

ANNEX 6: Additional Information: Quality Controls including Australia's National Carbon Balance	126
A6.1 Additional information on the QA/QC Plan	126
A6.2 Australia's National Carbon Balance	130
A6.3 Summary of Responses to UNFCCC ERT Recommendations and Comments	140
ANNEX 7: Description of Australia's National Registry	157
A7.1 Name and contact information of the registry administrator designated by the Party to maintain the national registry	157
A7.2 Names of any other party with which the party cooperates by maintaining their respective registries in a consolidated system	157
A7.3 A description of the database structure and capacity of the national registry	157
A7.4 A description of how the national registry conforms to the technical standards for the purpose of ensuring the accurate, transparent and efficient exchange of data between national registries, the clean development registry and the independent transaction log, including (i) to (vi) below	159
A7.5 Identification and Authentication	160
A7.6 Access control	160
A7.7 Access protection	161
A7.8 A list of the information publicly accessible through the user interface to the national registry	162
A7.9 An explanation of how to access information through the user interface of the national registry	163
A7.10 Measures to safeguard, maintain and recover data in the event of a disaster	163
A7.11 Results of previous test procedures	163
ANNEX 8: Report to Facilitate the Calculation of Australia's Assigned Amount for the second commitment period of the Kyoto Protocol	164
A8.1 Introduction	164
A8.2 Requirements of the report to facilitate the calculation of the assigned amount for the CP2	164
ANNEX 9: General Notes, Glossary and Abbreviations	170
A9.1 General Notes	170
A9.2 Glossary	172
A9.3 Abbreviations	176
ANNEX 10: References	181

List of figures

Figure 11.1:	Location (in red) of land included in the deforestation account for 2013	9
Figure 11.2:	Location (in green) of plantation land included in the afforestation/reforestation account for 2013	12
Figure 11.3:	Comparison of four bushfire datasets over a portion of multiple-use public forests in Victoria.	23
Figure 11.4:	Validation of MODIS burnt area (orange), AVHRR burnt area (yellow) using the fire history data from Queensland (blue) derived from Landsat satellites. Black dots represent sampling points	24
Figure 11.5:	AVHRR based burnt area frequency for the period from 1988 to 2014	25
Figure 11.6:	Year since last burn for the period from 1988 to 2014. Inset map shows the distribution of <i>forest management</i> Lands in Australia	25
Figure 11.7:	Decision tree to support the development of a natural disturbance background level that is consistent with the IPCC background level quality criteria	27
Figure 11.8:	Wildfire burnt CO ₂ emissions on <i>forest management</i> land and trend line, excluding CO ₂ emissions associated with salvage logging	28
Figure 11.9:	Comparison of emissions trend across the selected calibration period and of a longer calibration period (1995-2012)	29
Figure 11.10:	Background level and background level plus margin based on the 2000-2012 calibration data set.	30
Figure 11.11:	Relationship between wildfire area burnt and the area of salvage logging	31
Figure 11.12:	Monitoring and classification of <i>forest management</i> land following a forest cover loss event	35
Figure 11.13:	Comparison of recalculated reference level emissions (FMRLcorr) with previous estimates (FMRL)	42
Figure 11.14:	Forest production in Australia (1991-2013)	45
Figure 11.15:	Correlation of estimated emissions from forest management and native forest log production (2002-2013)	48
Figure A6.1:	Balance flow chart showing carbon inputs and distribution of outputs for 2013*	132
Figure A6.2:	Fugitive gas balance flow chart for underground mines, 2013	133
Figure A6.3:	Fugitive gas balance flow chart for open cut mines, 2013	134
Figure A7.1:	ANREU Logical Network Topology (Production Environment)	158

List of tables

Table 11.1:	Selection of parameters for defining ‘Forest’ under the KP.	2
Table 11.2:	Reconciliation table between UNFCCC and KP classifications	5
Table 11.3:	Monitoring period for Article 3.3 and 3.4 lands	6
Table 11.4:	Area of land monitored for land-use change by jurisdiction	6
Table 11.5:	Land area subject to KP LULUCF activities in 2013	7
Table 11.6:	Summary of methodologies and emission factors –KP Land Use Change activities	7
Table 11.7:	Area of <i>deforestation</i> 1990-2013	8
Table 11.8:	Estimated net emissions from <i>deforestation</i> (k t CO ₂ -e)	10
Table 11.9:	Estimated AAUs to be cancelled for <i>deforestation</i> net emissions (kt CO ₂ -e)	10
Table 11.10:	Reconciliation of emissions from UNFCCC <i>forest conversion</i> and KP <i>deforestation</i> and other classifications	11
Table 11.11:	Area of <i>afforestation/reforestation</i> 1990-2013	12
Table 11.12:	Estimated net emissions from <i>afforestation/reforestation</i> (k t CO ₂ -e)	18
Table 11.13:	Estimated Accounting Quantity for <i>afforestation/reforestation</i> (kt CO ₂ -e)	18
Table 11.14:	Land subject to <i>forest management</i>	19
Table 11.15:	Forest management reference level harvest rates	20
Table 11.16:	Components of Australia’s background level and margin	26
Table 11.17:	Test of the balance criterion for a background level based on the 2000-2012 calibration group	29
Table 11.18:	Adaptation of Australia forest genera to fire	36
Table 11.19:	Technical correction by sub-category – summary	37
Table 11.20:	Elements of technical correction and cross-reference with IPCC <i>good practice</i> guidance	38
Table 11.21:	Summary table for reporting of technical correction	42
Table 11.22:	Estimated emissions from <i>forest management</i> (ktCO ₂ -e)	46
Table 11.23:	Estimated accounting quantity for Forest management (kt CO ₂ -e)	46
Table 11.24:	Native forest harvesting reference level and key activity data	47
Table 11.25:	Time series comparison of FMRL and reporting of <i>forest management</i>	47
Table 11.26:	Reconciliation of UNFCCC forest lands and <i>forest management</i> lands	49
Table 11.27:	Reconciliation of <i>forest management</i> with <i>forest land remaining forest land</i> emissions (Mt CO ₂ e)	50
Table 11.28:	Estimated emissions from <i>cropland management</i> (ktCO ₂ -e)	54
Table 11.29:	Estimated accounting quantity for <i>cropland management</i> (kt CO ₂ -e)	54
Table 11.30:	Estimated emissions from <i>Grazing land management</i> (ktCO ₂ -e)	58
Table 11.31:	Estimated accounting quantity for <i>grazing land management</i> (ktCO ₂ -e)	58
Table 11.32:	Summary overview for key categories for land use, land use change and forestry activities under the Kyoto Protocol.	59
Table 12.1:	SEF Table 1, Total quantities of Kyoto Protocol units by account type at beginning of reported year (CP1)	61
Table 12.2:	SEF Table 2(a), Annual internal transactions (CP1)	62
Table 12.3:	SEF Table 2(b), Annual external transactions (CP1)	63
Table 12.4:	SEF Table 2(c), Total annual transactions (CP1)	63
Table 12.5:	SEF Table 3, Expiry, cancellation and replacement (CP1)	64
Table 12.6:	SEF Table 4, Total quantities of Kyoto Protocol units by account type at end of reported year (CP1)	65
Table 12.7:	SEF Table 5(a), Summary information on additions and subtractions (CP1)	66
Table 12.8:	SEF Table 5(b), Summary information on replacement (CP1)	67

Table 12.9:	SEF Table 5(c), Summary information on retirement (CP1)	67
Table 12.10:	SEF Table 6(a), Memo item: Corrective transactions relating to additions and subtractions (CP1)	67
Table 12.11:	SEF Table 6 (b), Memo item: corrective transactions relating to replacement (CP1)	67
Table 12.12:	SEF Table 6(c), Memo item: Corrective transactions relating to retirement (CP1)	67
Table 12.13:	SEF Table 1, Total quantities of Kyoto Protocol units by account type at beginning of reported year (CP2)	68
Table 12.14:	SEF Table 2(a), Annual internal transactions (CP2)	69
Table 12.15:	SEF Table 2(b), Annual external transactions (CP2)	70
Table 12.16:	SEF Table 2(c), Annual transactions between PPSR accounts (CP2)	70
Table 12.17:	SEF Table 2 (d) Share of proceeds transactions under decision 1/CMP.8, paragraph 21 – Adaptation Fund (CP2)	70
Table 12.18:	SEF Table 2(e), Total annual transactions (CP2)	71
Table 12.19:	SEF Table 3, Expiry, cancellation and replacement (CP2)	71
Table 12.20:	SEF Table 4, Total quantities of Kyoto Protocol units by account type at end of reported year (CP2)	72
Table 12.21:	SEF Table 5(a), Summary information on additions and subtractions (CP2)	73
Table 12.22:	SEF Table 5(b), Summary information on annual transactions	73
Table 12.23:	SEF Table 5(c), Summary information on annual transactions between PPSR accounts (CP2)	74
Table 12.24:	SEF Table 5(d), Summary information on expiry, cancellation and replacement (CP2)	74
Table 12.25:	SEF Table 5(e), Summary information on retirement (CP2)	75
Table 12.26:	SEF Table 6(a), Memo item: Corrective transactions relating to additions and subtractions	75
Table 12.27:	SEF Table 6 (b), Memo item: corrective transactions relating to replacement	75
Table 12.28:	SEF Table 6(c), Memo item: Corrective transactions relating to retirement (CP2)	75
Table 12.29:	Accounting of Kyoto Protocol Units	76
Table 12.30:	Information table on accounting for activities under articles 3.3 and 3.4 of the Kyoto Protocol	78
Table 13.1:	Change to the national system	80
Table 14.1:	Change to the national registry	81
Table A1.1:	Key categories for Australia's 2012 inventory-level assessment including LULUCF	86
Table A1.2:	Key categories for Australia's 2012 inventory – trend assessment including LULUCF	88
Table A1.3:	Key categories for Australia's 2012 inventory – summary including LULUCF	91
Table A1.4:	Key categories for Australia's 2012 inventory-level assessment excluding LULUCF	93
Table A1.5:	Key categories for Australia's 2012 inventory – trend assessment excluding LULUCF	95
Table A1.6:	Key categories for Australia's 2012 inventory – summary excluding LULUCF	98
Table A1.7:	Summary overview for key categories for Land use, Land-use Change and Forestry activities under the Kyoto Protocol – 2012	100
Table A1.8:	Key categories for Australia's 1990 inventory-level assessment including LULUCF	101
Table A1.9:	Key categories for Australia's 1990 inventory-level assessment excluding LULUCF	103
Table A2.1:	General reporting table for uncertainty including LULUCF	107
Table A2.2:	General reporting table for uncertainty excluding LULUCF	110
Table A2.3:	Quantified uncertainty values for key stationary energy subcategories	113
Table A2.4:	Quantified uncertainty values for mobile source categories	114
Table A2.5:	Emissions and quantified uncertainty values for key transport subcategories	115
Table A2.6:	Quantified uncertainty values for key fugitive emissions subcategories	115
Table A2.7:	Quantified uncertainty values for key industrial processes subsectors using different techniques	117
Table A.2.8:	Relative uncertainty in emission estimates for the livestock subsector	118

Table A2.9:	Estimation of uncertainties in components of the land use change and forestry subsectors	119
Table A2.10:	Relative uncertainty in emission estimates for key waste subsectors	119
Table A2.11:	Specific distributions, parameters and results: Solid Waste	120
Table A6.1:	Summary of principal mitigation strategies and quality control measures	127
Table A6.2:	Australia's National Carbon Balance 2012	130
Table A6.3:	Underground mining raw coal production, by coal field	135
Table A6.4:	Australian Petroleum refining activity data	136
Table A6.5:	Stock of carbon in Australia's living forests, 2001-10	139
Table A6.6(a):	Summary of responses to UNFCCC ERT recommendations: energy and cross cutting	140
Table A6.6(b):	Summary of responses to UNFCCC ERT recommendations: Industrial processes	144
Table A6.6(c):	Summary of responses to UNFCCC ERT recommendations: Agriculture	146
Table A6.6(d):	Summary of responses to UNFCCC ERT recommendations: WASTE	148
Table A6.6(e):	Summary of responses to UNFCCC ERT recommendations: Land Use Land Use Change and Forestry	149
Table A6.6(f):	Summary of responses to UNFCCC ERT recommendations: ARTICLE 3.3 ACTIVITIES	156
Table A8.1:	Determination of Australia's Assigned Amount	166
Table A8.2:	Calculation of the threshold for AAU cancellation under Article 3.7 ter	166
Table A8.3:	Calculation of the commitment period reserve	167
Table A8.4:	Accounting mode elected by Australia for Article 3.3 and Article 3.4 activities	168
Table A8.5:	Components of Australia's background level and margin for wildfire natural disturbances	169

PART 2:

SUPPLEMENTARY
INFORMATION REQUIRED
UNDER ARTICLE 7.1 OF THE
KYOTO PROTOCOL

11. KYOTO Protocol LULUCF

In accordance with decision 1/CMP.8, this Part of the Report contains supplementary information to fulfil reporting requirements under Article 7 of the KP (decisions 6/CMP.9, 2/CMP.8, 2 and 4/CMP.7, 15/CMP.1 and as set out in draft decision FCCC/SBSTA/2014/L.29¹) and net emissions estimates compiled using reporting rules and guidance applicable to the KP CP2, including guidance contained in IPCC 2014.

Decision 1/CMP.8 provides that, pending the entry into force of the KP Doha Amendment that establishes the CP2 (2013 – 2020), KP Parties will continue to implement KP commitments and other responsibilities in a manner consistent with their national legislation and domestic processes. The information contained in this Report will be used for KP compliance purposes, however, only at such time as the Australian Government ratifies the Doha Amendment to the KP.

11.1 General Information

11.1.1 Definition of forest and other criteria

Forests include all vegetation with a tree height of at least 2 metres and crown canopy cover of 20 per cent or more and lands with systems with a woody biomass vegetation structure that currently fall below but which, *in situ*, could potentially² reach the threshold values of the definition of forest. Young natural stands and all plantations which have yet to reach a crown density of 20 per cent or tree height of 2 metres are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of either human intervention, such as harvesting, or natural causes, but which are expected to revert to forest.

The forest cover definition is consistent with the definition used in Australia's National Forest Inventory that has been used for reporting to the Food and Agriculture Organisation and Montreal Process. Australia has adopted a minimum forest area of 0.2 ha (Table 11.1).

Forest use is typically evident by human disturbance, such as in commercial forest harvest, or clearly delineated by land tenure, such as conservation reserves. In extensive systems, such as grazed woodlands, there is a continuum in the intensity and intent of use.

Table 11.1: Selection of parameters for defining 'Forest' under the KP.

Parameter	Range	Selected value
Minimum land area	0.05 – 1 ha	0.2
Minimum crown cover	10 – 30%	20
Minimum height	2 – 5 m	2

¹ <http://unfccc.int/resource/docs/2014/sbsta/eng/l29.pdf>

² This potential is evidenced from the Landsat series in that the land has previously supported forest.

11.1.2 Elected activities under Article 3.4

For CP2, Australia will report on *forest management* and has elected to report emissions and removals from the following Article 3.4 activities:

- *cropland management*
- *grazing land management*
- *revegetation*.

11.1.3 Precedence conditions and hierarchy among Article 3.4 activities

Australia has implemented a hierarchy of Article 3.4 activities into its land classification system. *Forest management*, as a mandatory activity takes precedence over the other Article 3.4 activities, consistent with IPCC requirements. The hierarchy of Article 3.4 activities is applied as follows:

- 1) *forest management*;
- 2) *cropland management*;
- 3) *grazing land management*; and
- 4) *revegetation*.

Australia's system for the classification of land in the UNFCCC and KP LULUCF inventories is described in more detail in Appendix 6.I.

11.2 Land-Related Information

11.2.1 Description of how the definitions of each activity under Article 3.3 and 3.4 have been implemented and applied consistently over time

Deforestation under the KP is a subset of *forest conversion* and includes only lands where there has been direct human-induced conversion of forest to alternative land uses since 1 January 1990.

Conversion of *forest lands* to alternative land uses prior to 1990 are accounted for under *cropland management* or *grazing land management* to enable complete accounting under CP2.

Forest management is a subset of *forest land remaining forest land* and includes those forests managed under a system of practices designed to support commercial timber production such as harvest or silvicultural practices or practices that are designed to implement specific sink enhancement activities.

Forests included under this definition include multiple-use public forests, plantations established prior to 1990, privately managed native forest land where *forest management* activities (harvesting and silvicultural practices) have been observed to occur; and forests where regulated sink enhancement activities occur.

Forest lands outside of the multiple-use public forests and pre-1990 plantation lands are also monitored for signs of harvesting and silvicultural practices in order to achieve complete accounting for these management practices. If a harvest event is observed, the net emissions are reported under the *forest management* category and all future net emissions on that land continue to be reported under that category.

Afforestation/reforestation is a subset of *land converted to forest land* and includes only those forests established since 1 January 1990 on land that was clear of forest on 31 December 1989. Forests under *land converted to forest land* may be established through planting events either for commercial timber or for other reasons, known as ‘environmental plantings’, or by regeneration from natural seed sources on lands regulated for the protection of forests.

Cropland management includes all land that is used for continuous cropping, lands managed as crop-pasture rotations and *land converted to cropland from grassland*. As noted above, *Forest land converted to cropland* prior to 1990 is also included under *cropland management*. *Land converted to forest land* is excluded from *croplands*.

Perennial crops including orchards and vineyards are included under *cropland management*. Units of land where orchards were established on land clear of forest on 31 December 1989 are included in the *cropland management* and not the *afforestation/reforestation* classification.

Grazing land management lands include *grasslands*, forests in northern Australia monitored for ‘savanna burning’ and forests established by regeneration from natural seed sources on lands not regulated for the protection of forests (and which are not classified as *afforestation/reforestation*).

Forest lands are not double counted in Australia’s land classification systems as Australia has applied a ‘narrow’ approach to *forest management*, allowing certain specified forests not identified as being managed for timber to be included under *grazing land management*. A forest observed to be deforested, or observed to be subject to a forest management practice, is reported under those categories in preference to *grazing land management* in accordance with the hierarchy used for Australia’s inventory.

Revegetation includes establishment of vegetation that covers a minimum area of 0.05 hectares and does not meet the definitions of *afforestation/reforestation*. It is restricted to settlements and wetlands.

While there are some essential differences between the KP and UNFCCC classification systems, it is possible to reconcile them and to demonstrate the differences that exist. For the most part, the differences have become either less pronounced or less significant as the coverage of land activities adopted by the Australian Government has increased over time. In Table 11.2, a concordance between UNFCCC and KP classifications used in the preparation of net emission estimates in this Report is presented.

Table 11.2: Reconciliation table between UNFCCC and KP classifications

UNFCCC	KP
<i>Forest land</i>	
<i>Forest land</i> – multiple-use public forest	<i>forest management</i>
<i>Forest land</i> – pre-1990 plantations	<i>forest management</i>
<i>Forest land</i> – harvested private native forests	Monitored for <i>forest management</i> activity
<i>Forest land</i> – conservation reserves	Monitored for <i>forest management</i> activity
<i>Forest land</i> – other native forest	Monitored for <i>forest management</i> activity
<i>Forest land</i> – savanna burning	<i>grazing land management</i>
<i>Land converted to forest</i>	
New plantations since 1990	<i>afforestation/reforestation</i>
Native regeneration since 1990 – direct human-induced	<i>afforestation/reforestation</i>
<i>Cropland</i>	
<i>Cropland</i> – permanent	<i>cropland management</i>
<i>Forest land converted to cropland</i> since 1990	<i>deforestation</i>
<i>Forest land converted to cropland</i> prior to 1990	<i>cropland management</i>
<i>Grassland converted to cropland</i>	<i>cropland management</i>
<i>Grassland</i>	
<i>Grasslands</i> – permanent	<i>grazing land management</i>
<i>Forest land converted to grassland</i> since 1990	<i>deforestation</i>
<i>Forest land converted to grassland</i> – pre-1990 conversion	<i>grazing land management</i>
<i>Settlements</i>	<i>revegetation</i> may occur
<i>Wetlands</i>	<i>revegetation</i> may occur

11.2.2 Identification of geographical locations

All lands under the reporting categories of *afforestation/reforestation*, *deforestation*, *cropland management* and *grazing land management* are monitored using a reporting method two land identification system (IPCC, 2014, Chapter 2.2.2) based on the Landsat time series in conjunction with ABARES Land Use Map Version 5. The methods of mapping forest extent and change in extent are outlined in Chapter 6 (Appendix 6.A).

The exact geographic location of each unit of land entering the *afforestation/reforestation* and *deforestation* accounts is mapped at 25 m resolution using continental coverages of Landsat data.

Land is tracked and simulated in FullCAM at a pixel by pixel (25m²) level and the carbon stock change on each pixel is tracked from the start of the simulation to the reporting year. The outputs of the simulations are stored in a datacube which can be queried using the FullCAM Outputs Analysis System (OASys).

The consistent tracking through time of individual units of land down to 0.2 ha results in millions of estimation units. For the purpose of reporting under Article 3.3 and Article 3.4 the areas are summed into larger reporting units. This is achieved by co-locating the areas of change on maps that represent logical identification codes. The initial divisions are the Australian states and territories. For *afforestation/reforestation* the areas are then reported by 3 broad types of forest: softwood, hardwood and native. Allocations to these classifications are obtained from more detailed analysis of the Landsat data (see Appendix 6.A).

Lands subject to *forest management* are monitored under reporting method 1 under IPCC (2014) Chapter 2.2.

11.2.3 Methodology used to develop the land transition matrix

The land transition matrix is developed using the forest extent data derived from Australia's Landsat archive consistent with the data for the UNFCCC reporting categories (Table 6.4 in Section 6.4).

11.2.3.1 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

Land where forest cover loss is identified as being human-induced and where it is not expected that the forest will be regenerated or replanted is classified as *deforestation* land.

In cases where there is a temporary change in forest cover due to natural events (e.g. fire, drought) or where changes occur within a land tenure where it is expected that the land will revert to forest (e.g. harvested forest, national park), the land is monitored for a period of time, depending upon the land tenure and use, consistent with the guidance provided in section 2.6.2.1 of IPCC 2014 (Table 11.3).

Areas that have entered the monitoring system continue to be classified as *forest land* provided that the time since forest cover loss is shorter than the number of years within which tree establishment is expected (Table 11.3). After the specified monitoring period, however, lands that have lost forest cover due to direct human-induced actions, have undergone land use change, and failed to regenerate are classified as *deforestation*.

Table 11.3: Monitoring period for Article 3.3 and 3.4 lands

Land classification	Monitoring period (x years)
<i>afforestation/reforestation</i>	8
<i>forest management</i>	12

11.2.3.2 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

The area of land identified as being harvested and where re-establishment has not been confirmed is approximately 632,573 hectares (Table 11.4). The general rate of regeneration of softwood plantation estates in Australia is generally high – 93% for Tasmania and 98-100% for South Australia (Montreal Process Implementation Group for Australia 2008) – but may be significantly less for hardwood plantations.

Table 11.4: Area of land monitored for land-use change by jurisdiction

Jurisdiction	Area of land monitored (k ha)
Australian Capital Territory	5
New South Wales	134
Northern Territory	1
Queensland	86
South Australia	23
Tasmania	62
Victoria	180
Western Australia	142
Total	633

Table 11.5: Land area subject to KP LULUCF activities in 2013

Activity	Area in 2013 (k ha)
Afforestation and Reforestation	3,255.64
Deforestation	7,253.79
Forest Management ^(a)	11,010.12
Cropland Management	35,866.98
Grazing Land Management	561,102.93
Revegetation	NO
Wetland drainage and rewetting	NA
Other	150,510.54
Total	769,000.00

(a) The area subject to forest management reported in this table includes annual land conversions to deforestation. The total area under forest management (section 11.6.1) used to estimate the FMRL and estimate of emissions from forest management takes into account future deforestation up until the year 2020 in accordance with page 2.94 of the IPCC 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol.

11.3 Methods for carbon stock changes and greenhouse gas emissions and removal estimates

In general, a tier 3, Approach 3 (reporting method 2 under IPCC (2014)) system is used to estimate emissions and removals under Article 3.3 and 3.4 using the same methods as used to estimate the UNFCCC inventory (Chapter 6). Tier 2 methods are used for biomass burning and for emissions and removals under *forest management*, consistent with the methods used for corresponding categories in the UNFCCC inventory (Chapter 6).

Table 11.6: Summary of methodologies and emission factors –KP Land Use Change activities

Greenhouse Gas Source And Sink	CO ₂		CH ₄		N ₂ O	
	Method applied	EF	Method applied	EF	Method applied	EF
Article 3.3 activities						
Afforestation/Reforestation						
C stock changes	T3	M				
Biomass burning ^(a)	IE	IE	CS	CS	CS	CS
Deforestation						
C stock changes	T3	M				
Biomass burning ^(a)	IE	IE	CS	CS	CS	CS
Article 3.4 activities						
Forest management						
C stock changes	T2	M				
Biomass burning ^(a)	T2	CS	CS	CS	CS	CS
Cropland management						
C stock changes	T3	M				
Biomass burning ^(a)	IE	IE	CS	CS	CS	CS
Grazing land management						
C stock changes	T3	M				
Biomass burning ^(a)	T2	CS	CS	CS	CS	CS

(a) CO₂ emissions and removals associated with biomass burning are included in the C stock changes.

EF = emission factor, CS = country specific, M = Model, NO = not occurring, IE=included elsewhere, T1 = Tier 1 and T3 = Tier 3.

11.3.1 Years for which carbon stock changes and non-CO₂ emissions are reported

Carbon stock changes and non-CO₂ emissions from land subject to Article 3.3 and Article 3.4 activities will be reported from the start of the commitment period in 2013.

11.3.2 Information that demonstrates that Article 3.3 activities began on or after 1 January 1990 and are direct human-induced

The land is monitored using a time series of Landsat imagery since 1972 in order to be able to demonstrate the date at which the Article 3.3 activities began.

11.3.3 Factoring out of indirect and natural emissions and removals

Indirect effects on greenhouse gas emissions and removals are not explicitly factored out although, as Australia's estimation methods utilise a process-based tier 3, modelling approach it is clear that the relationships between biomass, climate and atmospheric concentrations are fixed for the time series of emission estimates.

Natural emissions and removals are managed through the application of the natural disturbance provision for a range of identified natural disturbances under *forest management*. Five-year moving averages of emissions estimates are reported for savanna burning sources and sinks ensure that the inventory reports trends and systematic changes in carbon stocks and is not overly influenced by inter-annual variability or natural disturbances.

11.3.4 Uncertainty estimates

Uncertainty estimates are provided in Annex 2.

The same methods and data are used to estimate emissions and removals due to in all Article 3.3 and 3.4 activities as are used for the associated UNFCCC categories.

11.4 Deforestation

11.4.1 Identification of land subject to *deforestation*

Deforestation activity (Table 11.7) is identified using methods applied to the identification of *forest conversion* under the UNFCCC and described in Appendix 6.A. *Deforestation* only includes lands where there has been direct human-induced conversion of forest to alternative land uses since 1 January 1990.

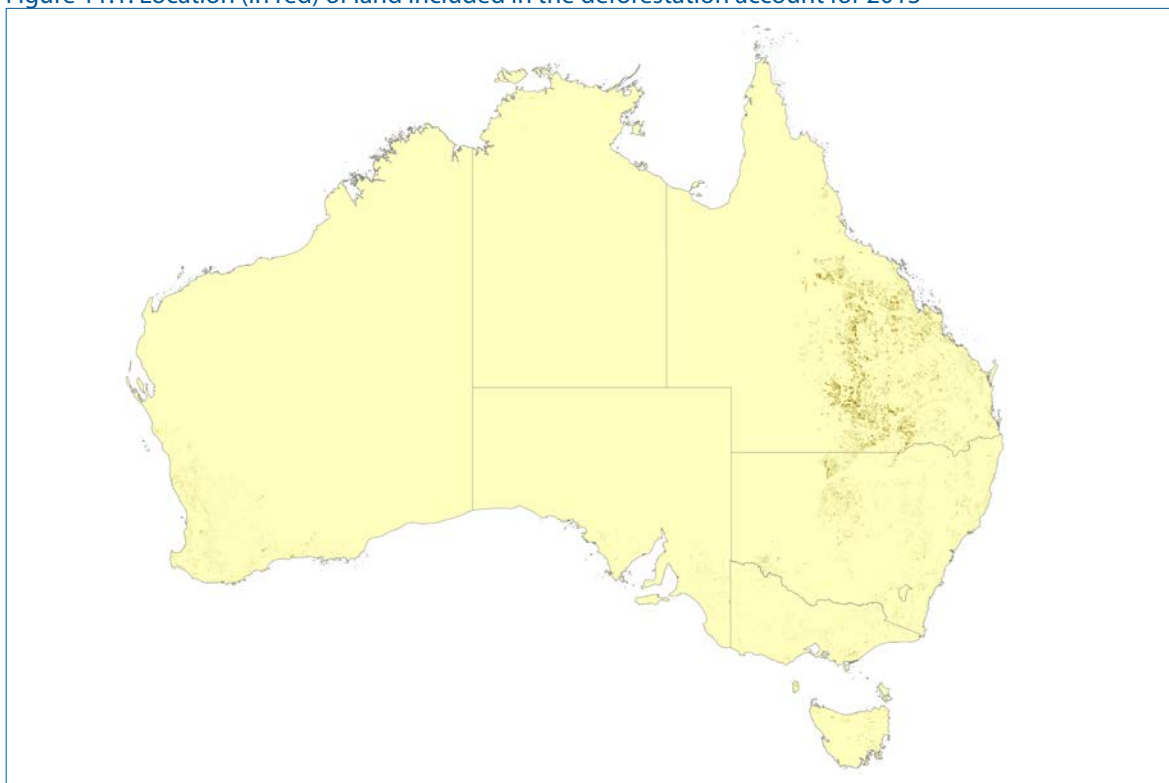
Table 11.7: Area of *deforestation* 1990-2013

Year	Area of deforestation (M ha)
1990-1994	2.04
1995-1999	1.54
2000-2004	1.64
2005-2009	1.47
2010-2013	0.57

11.4.1.1 Spatial identification of *deforestation* lands

The location of land included in the *deforestation* account is shown in Figure 11.1.

Figure 11.1: Location (in red) of land included in the *deforestation* account for 2013



11.4.2 Methods for estimation of carbon stock changes and greenhouse gas emissions and removal estimates

11.4.2.1 Data

The same data sources are used for *deforestation* as for *forest conversion*, as detailed in Volume 2.

11.4.2.2 Methods

The same tier 3, Approach 3 (reporting method 2 under IPCC (2014)) system is used for *deforestation* as that used to estimate *forest conversion* (see Appendices 6.B and 6.F).

11.4.2.3 Start year

Estimation of net emissions is undertaken from 1972 consistent with the available Landsat series.

11.4.2.4 Carbon pools

FullCAM estimates emissions from soil as a result of an estimation process involving all on-site carbon pools (living biomass, dead organic matter and soil).

11.4.3 Reporting of *deforestation* in 2013

11.4.3.1 Reporting of *deforestation* net emissions in 2013

Estimates of net emissions from *deforestation* are reported in Table 11.8.

Table 11.8: Estimated net emissions from *deforestation* (k t CO₂-e)

	Total
2000	68,924
2005	85,862
2008	55,683
2009	52,403
2010	51,285
2011	37,322
2012	38,130
2013	37,190

11.4.3.2 Estimation of AAUs to be cancelled for *deforestation* in 2013

In the reporting period, 2013–2020, one AAU is to be cancelled for every tonne of emissions reported from the *deforestation* activity (the same approach as for emissions from sources in the *energy, industrial processes and product use, agriculture, waste* sectors). An estimate of AAUs to be cancelled in 2013 is presented in Table 11.9.

For land categories other than *deforestation* the accounting treatment is different. For land categories other than *deforestation*, credits (called RMU credits) are to be issued against the reduction in net emissions relative to a specified benchmark base year or reference level – or units are cancelled for any increase in net emissions relative to a specified benchmark base year or reference level.

Table 11.9: Estimated AAUs to be cancelled for *deforestation* net emissions (kt CO₂-e)

	AAUs to be cancelled
2013	37,190

11.4.4 Quality Assurance – Quality Control

Table 11.10 provides a reconciliation between emissions reported under the KP *deforestation* account (Table 11.10, Components A and B) and the UNFCCC *forest land converted to cropland* and *forest land converted to grassland* classifications. Differences between these two classifications arise because the *deforestation* account does not include:

- Land in a *forest conversion* classification that was clear of forest on 31 December 1989 that has naturally regrown and had not been re-cleared (this land is classified as either *afforestation/reforestation* or *grazing land management* land) (Component C); and
- the ongoing emissions and removals from land cleared prior to 1990 that has remained cleared (this land is classified as either *cropland management* or *grazing land management* land) (Table 11.10, Component D).

Table 11.10: Reconciliation of emissions from UNFCCC *forest conversion* and KP *deforestation* and other classifications

	Deforestation Forest in 1990 (Gg CO ₂ -e)	Deforestation Clear 1990, regrown (Not classified as A/R) and cleared post 1990 (Gg CO ₂ -e)	AR / GM Clear 1990, regrown and remains forest (Gg CO ₂ -e)	GM / CM Clear 1990, Remains clear (Gg CO ₂ -e)	Total UNFCCC Forest land converted to other land uses (Gg CO ₂ -e)
Component	A	B	C	D	A+B+C+D
2008	53,076	2,472	-449	2,769	57,869
2009	49,249	3,022	-149	6,213	58,336
2010	47,741	3,275	-516	9,683	60,183
2011	34,516	2,652	-835	-737	35,596
2012	35,016	2,969	-448	5,217	42,755
2013	33,865	3,186	-443	4,639	41,247

NOTE: Nitrous oxide emissions due to soil disturbance are not included in these comparisons.

11.4.5 Recalculations

There are no recalculations as 2013 is the first year of the commitment period.

The historical timeseries of net emissions from *forest conversion* has been re-estimated due to new activity data and is reported in Chapter 6.

11.5 Afforestation & Reforestation

11.5.1 Identification of land subject to *afforestation/reforestation*

Afforestation/reforestation activity is identified using methods applied to the identification of *land converted to forest* under the UNFCCC and described in Appendix 6.A. Plantations for timber, environmental plantings and the promotion of natural seed sources are included within the *afforestation/reforestation* classification.

The natural regeneration of forests from natural seed sources are identified in areas consistent with the intentions of land use regulatory systems and reflect the deliberate decisions of land managers to not maintain pasture for grazing. To qualify as a *forest land* converted from natural seed sources, the land must have been clear of forest in the period 1972-1989 and must have converted to forest land after 1 January 1990.

Conversions to forest land can be supported through a range of government programs and regulatory processes including from offsets created under State vegetation management acts or under major project approval processes. The *Emission Reduction Fund* is also able to be used to encourage these outcomes.

The identification of regeneration of forest from natural seed sources as *afforestation/reforestation* is explained further in section 1.5.1.2 below. The area of *afforestation/reforestation* is presented in Table 11.11.

Table 11.11: Area of *afforestation/reforestation* 1990-2013

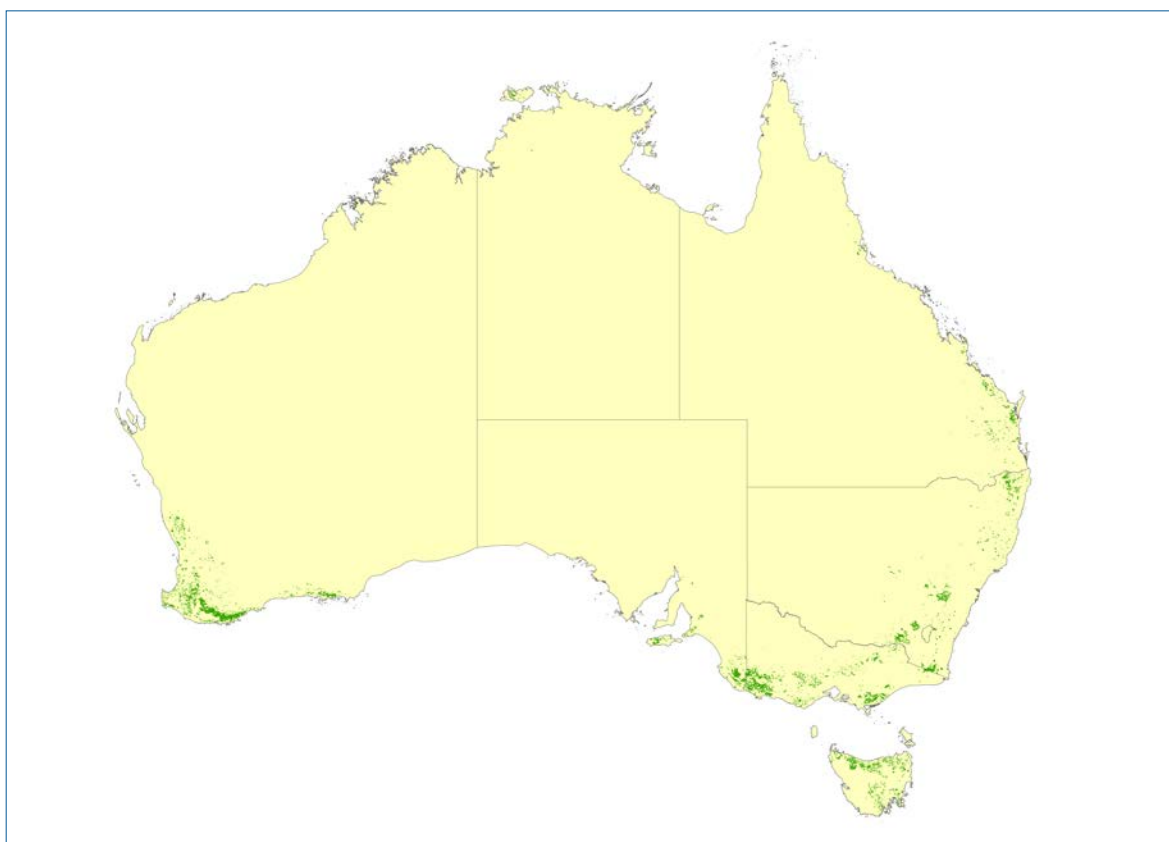
Year	Area of <i>afforestation/reforestation</i> (M ha)
1990-1994	0.63
1995-1999	0.51
2000-2004	0.72
2005-2009	0.84
2010-2013	0.65

Australia's *afforestation/reforestation* estate has increased in area over the period 1990-2013, especially in the five years from 2000. In 2013, however, the rate of *afforestation/reforestation* activity was the lowest since 1990 (Table 11.11). This may have been caused by the economic conditions for forest products, including the historically high value of the Australian currency in recent years, making it more challenging to export plantation products overseas.

11.5.1.1 Spatial identification of *afforestation/reforestation* lands

Afforestation/reforestation activities are identified in relation to a 1990 base map of forest land derived from the land monitoring program (Appendix 6.A). The location of land from plantings included in the *afforestation/reforestation* account for 2013 is shown in Figure 11.2.

Figure 11.2: Location (in green) of plantation land included in the *afforestation/reforestation* account for 2013



11.5.1.2 Identification of regeneration of native forests as *afforestation/reforestation*

It is estimated that there was approximately 2.18 million hectares of land which was not forest on 31 December 1989 (and was not forested at any time between 1972 and 1989), which was subsequently converted to *forest land* through natural regeneration and remained forest.

All lands in South Australia, Tasmania, Victoria and Western Australia have been identified as subject to land clearing restrictions. In Queensland, lands mapped as high value regrowth under the *Vegetation Management Act 1999* and land that is included in the Collaborative Australian Protected Area Database (CAPAD) is considered protected. In the remaining jurisdictions (Australian Capital Territory, New South Wales and the Northern Territory) further analysis of land clearing regulations is required to include all protected lands. In NSW, in particular, the area identified as protected is likely to be a significant under estimate. The focus of current analysis is to improve the estimated area of protected land in New South Wales.

Every two years, the Australian Government collects information on protected areas from state and territory Governments and other protected area managers published in the Collaborative Australian Protected Area Database (CAPAD).

CAPAD is used to provide a national perspective of the conservation of biodiversity in protected areas. It also allows Australia to regularly report on the status of protected areas to meet international obligations such as those in the Convention on Biological Diversity (CBD). Australian protected area information is also included in the World Database on Protected Areas (WDPA).

Australia has in force a framework of federal, state and territory legislation and guidelines regulating clearing of native vegetation and forests (see below). These laws establish a framework whereby land that has naturally regenerated to meet the forest definition has been allowed to do so as a result of a deliberate management decision not to clear those lands.

The direct intent of national policy is to target the native vegetation extent and to promote revegetation for that purpose. All native vegetation in Australia is managed within the National Vegetation Framework, and its predecessor intergovernmental agreements, which place clear value on the extent of native vegetation cover and the activity of revegetation in particular. The framework is comprehensive – it covers all native vegetation – and is relevant for all levels of government as evidenced by the large range of supporting federal and State government programs.

Consequences for land managers flow from the promotion of revegetation such that they have a legal need for activities to prevent an undesired regrowth of an area to forest and that the regrowth of an area as forest should take place only where desired by land managers based on land managers' decisions. In Australia, the legal consequences of promoting revegetation take two forms.

- 1) Revegetation activity may be directly supported by federal or state government financial assistance or regulatory incentives which make the management decision to promote revegetation more attractive. There are many government programs that directly or indirectly support revegetation activity where demonstration of revegetation activity is legally required in return for financial assistance. Moreover, it is common in many states, including Queensland and New South Wales, for explicit offset policies to operate whereby revegetation activity may be undertaken by the land manager as part of a legal agreement to offset the environmental impact of approval for clearing of other vegetation under certain conditions.
- 2) There are the regulatory or legal consequences of converting land to forest. Once a management decision is taken to promote revegetation, the vegetated land enters the State regulatory systems. Revegetated land falls under the scope of the National Vegetation Framework and, as such, is assessed by regulators for forest system values such as its representativeness of threatened regional ecosystems, provision of habitats for wildlife,

biodiversity, land and water quality values such as prevention of erosion and salinity and greenhouse gas net emissions. As a result, the development of forested land has significant management consequences for land managers.

Australia's native vegetation legislative framework

The *National Vegetation Framework* is an intergovernmental agreement among all levels of Australian government under the Council of Australian Governments (COAG). It provides for national objectives in relation to native vegetation cover, deforestation and 'revegetation'. In particular:

- the extent of native vegetation cover is an explicit policy objective;
- 'revegetation' is identified as a critical activity that contributes towards this national goal; and
- there is flexibility for individual States and Territories to implement the framework in accordance with their own individual circumstances.

The framework provides for an explicit national target for native vegetation cover – see <http://www.environment.gov.au/land/vegetation/nvf/pubs/native-vegetation-framework-summary.pdf>.

The National Vegetation Framework has been designed to be complementary and consistent with Australia's Strategy for the National Reserve System 2009-2030 in which state and territory Governments and the Australian Government have agreed to adopt international standards for the definition of a protected area and management categories used by the IUCN.

The new framework provides continuity with the objectives, principles and targets of earlier COAG agreements and intergovernmental initiatives stretching back to 1990 and before – the National Vegetation Framework (2001) and the landmark National Strategy for Ecologically Sustainable Development (1992), which still provides the framework and context for major legislative initiatives <http://www.environment.gov.au/epbc/review/publications/pubs/02-objectives.pdf>, and the National Conservation Strategy negotiated in 1983.

Underpinning these objectives has been a basic set of principles designed to encourage actions to achieve sustainable native vegetation management including principles drawing heavily from the National Strategy on Ecologically Sustainable Development (1992). The ESD strategy provided agreement on national vegetation cover objectives and management principles while recognising existing programs such as the One Billion Trees program, announced 20 July 1989. This is outlined in the following key objective:³

Objective 11.1 to foster a conservation ethic, while ensuring effective measures are in place for the conservation and management of native vegetation

Governments will:

- continue actions to promote whole-farm and catchment planning and group approaches to resource management in agriculture, such as those established under the National Soil Conservation Program, Save the Bush, the National Weeds Strategy, the One Billion Trees Program and the Decade of Landcare Plans (announced in the 20 July 1989 'Our Country Our Future' package)
- assess the current rate of native vegetation clearing on a national basis, including undertaking the development of national inventories of native vegetation
- support initiatives at the State and Territory level to protect native vegetation on private land, and enhance initiatives aimed at developing integrated catchment management policy structures
- work through appropriate agencies to develop a native vegetation conservation education program which is targeted at land managers, focuses on the value of retaining native vegetation in situ, while integrating this with major land uses
- review relevant legislation relating to clearing, and ensure criteria for assessing land clearance applications integrate

3 <http://www.environment.gov.au/about/esd/publications/strategy/natveg.html>

- enhancement of productivity of all lands with biodiversity conservation, land protection, water management and landscape values
- encourage voluntary management of native vegetation remnants, and review the effectiveness of mechanisms for the long term voluntary protection of native vegetation and wildlife, in order to provide a basis for deciding on the most appropriate mix
- undertake cooperative development of a range of measures, including financial incentives, cost reimbursements, and rate rebates to encourage land managers to better protect native vegetation

The succession of agreements under COAG has steadily advanced national vegetation protection principles and targets over an extended period of time providing clarity about the value placed on the conservation of native vegetation cover nationally, and on the national policy objective of enhancing revegetation, while providing a cohesive national framework to underpin State and Territory based management actions.

While dedicated vegetation management legislation emerged in some states in the 1990s, land management activities have been, and continue to also be, regulated by more general land planning legislation introduced prior to, or around, 1990. A more complete listing of relevant State and Territory legislation governing land clearing is provided below.

State and territory native vegetation clearance statutes

New South Wales

- *Native Vegetation Act 2003*
- *Threatened Species Conservation Act 1995*
- *Environmental Planning and Assessment Act 1979 (Local Environmental Plan)*

Victoria

- *Victorian Planning Provision (Clause 52.17)*
- *Planning and Environment Act 1987*
- *Flora & Fauna Guarantee Act 1988*
- *Catchment and Land Protection Act 1994*

Queensland

- *Vegetation Management Act 1999 (prior to this, the Land Act 1994 and the Environmental Protection Act 1994)*
- *Integrated Planning Act 1997*
- *Nature Conservation Act 1992*

Western Australia

- *WA Environmental Protection Act 1986*

South Australia

- *SA Native Vegetation Act 1991*

Tasmania

- *Tasmania Forest Practices Act 1985*

Australian Capital Territory

- *ACT Planning and Development Act 2007*
- *Nature Conservation Act 1980*

Northern Territory

- *NT Planning Act 2002*
- *NT Planning Scheme*
- *Pastoral Land Act 1994*

A primary aim of the emergence of specific – purpose legislation, such as Queensland's *Vegetation Management Act 1999*, was to unify and make more consistent existing regulatory measures and, in particular, ensure consistency between regulations that applied to leasehold and freehold land (government and private lands).

While the legislative instruments in place have clearly evolved, the list shows that relevant regulations to govern the management of native vegetation have been in place over a long period of time in all States and Territories.

Examples of administrative processes include compliance with regional ecosystem plans established under legislation, individually negotiated property management plans or additional approval processes/permit processes for clearing.

Permits for conversion of all forests to grasslands for agriculture are required in the Northern Territory, Western Australia, Victoria, South Australia and Tasmania, with minor exceptions. The relevant acts and regulations specify exemptions from the current approval process for the routine maintenance of agricultural land but only for lands with regrowth of an age that is less than a specified number of years (usually between five and ten years) and only where a permit to clear has been previously issued. Effectively a legal consequence through an approval process is associated with all revegetation actions.

In Queensland the administrative processes are more complex. Legal consequences derive from a combination of regional ecosystem plans issued under regulation, individual property agreements and land clearing permits.

For regulated regrowth in Queensland, which relates only to land with regrowth forest not cleared since 31 December 1989, forest areas of high conservation value identified by the relevant Minister in maps published under regulation are protected by permit approval processes. The technical nature of the assessment processes, and risks to land managers given uncertainty about outcomes following a series of well publicised prosecutions for non-compliance, has meant that there has also been considerable use of agreements known as property map of assessable vegetation plans. This represents an additional layer of approval process. These plans are individual legal agreements between the land manager and the State Government relating to specific properties and which identify both highly protected forests and forests where pre-approval for clearing is granted.

A similar mix of instruments is applied in New South Wales. Protected regrowth is native vegetation that has grown since 1 January 1990 (or 1983 in the Western District), but is protected because it has grown on vulnerable land or has been identified as protected regrowth in a Property Vegetation Plan (PVP), an environmental planning instrument, a natural resources management plan or an interim protection order under the NV Act. It also includes native vegetation that is regrowth that has been grown or preserved with the assistance of public funds granted for biodiversity conservation purposes.

The regulations provide for clearing of other regrowth areas for agriculture without additional approval only if the land had been lawfully cleared previously or for the continuation of existing cultivation, grazing or rotational farming practices. This latter provision is akin to the provisions of regulations in other states but without the specification of a specific number of years of regrowth. As with other states, this provision implies that the land manager may control for vegetation regrowth without further approval only for the purpose of maintaining existing pastures.

The national regulatory framework, together with the raft of legislative instruments and other policies and measures in place at national and State and Territory level, demonstrate that land managers have a legal need for activities to prevent an undesired regrowth of an area to forest and that the regrowth of an area as forest should take place only where desired by land managers based on land managers' decisions. *deforestation* of these lands is possible only under certain circumstances and several administrative steps must be taken before it is legally allowed.

At the national level, there are many relevant federal government programs which also aim to promote vegetation cover either directly or indirectly, such as through carbon or biodiversity objectives.

These measures continue past actions by the Federal government to promote vegetation outcomes across the country over a long period of time. For example, in the 'Our Country Our Future' package announced 20 July 1989, the measures included the National Soil Conservation Program, Save the Bush, the National Weeds Strategy, the One Billion Trees Program and the Decade of Landcare Plans. There have been many measures in the period between these two packages.

These federal government programs operate in addition to land management legislation operated by State and Territory governments identified above.

11.5.2 Methods for carbon stock changes and emissions and removal estimates

11.5.2.1 Data

The same data sources are used for *afforestation/reforestation* as for *land converted to forest land* in the UNFCCC inventory (see Appendix 6.A and 6.G).

11.5.2.2 Methods

For *afforestation/reforestation*, the same tier 3, Approach 3 system is used as for *land converted to forest land* under the UNFCCC inventory (see Appendix 6.A and 6.G). The use of the tier 3, Approach 3 (reporting method 2 under IPCC (2014)) system means that the combined reporting of *afforestation* and *reforestation* does not affect the area of land reported or estimates of the emissions and removals.

11.5.2.3 Start year

Estimation of net emissions is undertaken from 1972 consistent with the available Landset series.

11.5.2.4 Carbon pools

FullCAM estimates emissions from soil as a result of an estimation process involving all on-site carbon pools (living biomass, dead organic matter and soil).

11.5.3 Reporting of *afforestation/reforestation* in 2013

11.5.3.1 Reporting of *afforestation/reforestation* net emissions in 2013

Estimates of net emissions from *afforestation/reforestation* are reported in Table 11.12.

Table 11.12: Estimated net emissions from *afforestation/reforestation* (k t CO₂-e)

	Total
2008	-15,102
2009	-12,344
2010	-13,411
2011	-17,408
2012	-9,778
2013	-12,545

11.5.3.2 Estimation of *afforestation/reforestation* Accounting Quantity in 2013

For land activity categories other than *deforestation*, credits (called RMU credits) are issued against the reduction in net emissions relative to a specified benchmark base year or reference level.

For *afforestation/reforestation* estimates of net emissions in the reporting year are used to estimate the amount of RMU credits (the accounting quantity) to be issued. The estimated quantity of RMUs to be issued for 2013 is contained in Table 11.13.

Table 11.13: Estimated Accounting Quantity for *afforestation/reforestation* (kt CO₂-e)

	Accounting Quantity (RMU credits)
2013	12,545

11.5.4 Quality Assurance – Quality Control

Refer to Chapter 6.6.

11.5.5 Recalculations

There are no recalculations as 2013 is the first year of the commitment period.

The historical timeseries of net emissions from *land converted to forest* has been re-estimated due to new activity data and is reported in Chapter 6.

11.6 Article 3.4 activities – Forest management

Forest management comprises emissions and removals from *forest lands* that are managed under a defined system of practices, and includes emissions from harvested wood products and natural disturbances relating to *forest management* lands. Forest harvesting is the key driver of anthropogenic emissions and removals from *forest management* over the medium term.

In accordance with Decision 2/CMP.7, *forest management* is accounted against an emissions reference level that represents policies and practices in place as at December 2009. Australia's forest management reference level (FMRL) was reported in its 2011 *Forest Management Reference Level Submission* (DCCEE, 2011).

Identification of land subject to *forest management*

Forest lands are identified using methods applied to the identification of forest under the UNFCCC and described in Appendix 6.A. *Forest Management* lands are a subset of *Forest lands* identified using the narrow approach in accordance with practices specified in section 11.6.2.

Forest management lands include:

- all commercial plantations not included under Article 3.3 (i.e. plantations established on or before 31 December 1989);
- all public land available for timber harvesting as at December 2009, specifically multiple-use public forests as identified by the Montreal Process Implementation Group 2008;
- other forest lands (comprising forest lands that were in formal conservation reserves as at December 2009, privately managed native forests and extensively grazed woodlands) where the following activities are observed;
 - harvesting since 1990, and
 - direct human-induced activities which aim to recover the forest from a degraded state, such as enrichment planting, conducted after December 2009.

All forest lands are monitored for harvesting since 1990 because the management intent of forest land outside of plantations, multiple-use public forests and conservation areas is not known. Once an activity is identified, the land on which it occurs is transferred to the *forest management* lands account. This enables the balanced and complete accounting of emissions and removals over time from this activity.

Table 11.14 shows the area of land included under each of these components of *forest management*.

Table 11.14: Land subject to *forest management*

Forest management sub-classifications	Estimated area in 2013 (M ha)
Multiple use forests	9.25
Private native forests (where harvest has been observed and which have been included in <i>forest management</i>)	0.91
Pre-1990 plantations (commercial plantations not included under Article 3.3)	0.82
Total forest area	10.98

11.6.1 Identification of management practices

Forest management includes lands where management practices for the purpose of sustainable production of wood and wood fibre occur, such as:

- harvesting of forests, including thinning, selective harvesting and clearfell;
- silvicultural practices used for forest management;
- slash management, pest control, or fertilisation;
- protection of natural resources within the areas of land available for harvesting; and
- the application of codes of forest practice.

11.6.1.1 Policies included in the reference level projection

Australia has a comprehensive domestic framework designed to achieve the conservation and sustainable management of all of its forests. This framework includes:

- A national policy framework – Australia's 1992 National Forest Policy Statement (NFPS) promotes the conservation and sustainable management of forests.
- Regional Forest Agreements (RFAs) – RFAs have legal status via the national *Regional Forests Agreement Act 2002*. RFAs are 20 year plans underpinning regional approaches to balance conservation and production from native forests and cover the majority of production forest regions in Australia. In addition to forest conservation provisions, RFAs also provide certainty for sustainable timber supply.
- Australia's Sustainable Forest Management Framework of Criteria and Indicators 2008 – internationally recognised framework for sustainable forest management applied to Australia's forests.
- State and territory frameworks – jurisdictional legislation and codes of practice are applied to ensure environmentally responsible forestry practices.
- Forest certification – independent third party forest certification applies to most of Australia's production forests.

At the national level, Australia uses the international Montreal Process Criteria and Indicators as the framework for monitoring and measuring the management of forests.

Harvesting in native forests in Australia is regulated both at the national and State level. In 1992, Commonwealth and State governments agreed to a National Forest Policy statement establishing a regime for balancing ecologically sustainable forest management and harvesting with establishment of a Comprehensive, Adequate and Representative (CAR) reserve system to protect areas of environmental and heritage value such as old growth forests. This regime involved scientific research and consultation (called Comprehensive Regional Assessments) to support 20-year Regional Forest Agreements that provide certainty for forest-based industries, forest-dependent communities and conservation.

These agreements represent an important part of the policy context for regulating harvest rates in native multiple-use public forests in Australia. Regional Forest Agreements cover more than 39 million hectares, and in the four states New South Wales, Tasmania, Victoria and Western Australia nearly 17 million hectares are protected from logging under the CAR reserve system (MPIG, 2013). Additionally, the amount of wood that can be harvested from multiple-use public forests under Regional Forest Agreements is regulated using sustainable yield calculations designed to ensure the environmental attributes and the productive capacity of the forest are maintained. There are additional constraints on harvesting from native forests in areas that are reserved for conservation, water or heritage protection or other purposes. The application of codes of forest practice can also restrict harvesting in some areas (MPIG, 2013).

For native forests subject to harvesting (multiple-use public forests and harvested private native forests) inclusion of the relevant pre-2009 policies has been achieved by extrapolating the average harvest rates during the period 2002-2009 to the projection period. This projected harvest rate (Table 11.15) was used to model projected emissions during the FMRL period.

Table 11.15: Forest management reference level harvest rates

Harvesting area (ha)	
Reference Level harvesting (2002-2009 average)	91,804

For pre-1990 plantations, it is assumed in the reference level that harvesting occurs when plots reach maturity based on standard growth rates and rotation lengths, an assumption which is not affected by policy changes.

11.6.2 Methods used to establish the Forest Management Reference Level and for *forest management* reporting

11.6.2.1 Methods for estimating emissions in FMRL and reporting of *forest management*

The methods used in reporting of emissions from *forest management* and for calculation of the technical correction are described below in accordance with IPCC (2014), Chapter 2.7.2. Equivalent methods have been used for *forest management* as for the corresponding UNFCCC forest category (as described in Vol 2 Chapter 6). Consistent with *forest lands remaining forest lands*, emissions from *forest management* have been estimated using a tier 2, reporting method 1 approach (IPCC, 2006; IPCC, 2014).

The emissions and removals from multiple-use public forests and harvested private native forests are estimated using the non-spatially explicit Estate modelling capability of *FullCAM*. This model enables the use of age-based growth data and incorporates the effects of differing silvicultural treatments on the generation and management of harvest slash. The forest classification and related characteristics including biomass and growth rates used to estimate carbon stock changes and emissions are the same as those described for the *harvested native forests* model in Chapter 6.4.1.1. Management and harvesting practices used in the model are also described in Chapter 6.4.1.1, and in Chapter 6.5.3.1 regarding emissions from post-harvest regeneration burning (slash burning).

The annual change in living biomass in native forests subject to harvesting is the net result of uptake due to forest growth (above and belowground as determined from the growth models) and losses due to forest harvesting. The forest type and harvest type influence the proportions of biomass transferred to the harvested wood products pool or residue material (including belowground biomass) moved to dead organic matter.

The general approach to estimating carbon stock changes in HWPs is set out in Section 4G – Harvested Wood Products in Volume 2. The HWP model relies on the log harvest, HWP production and trade data contained in the Australian Forest Product Statistics (ABARES 2014a). In this submission, *forest management* includes HWP derived from softwood; all native hardwood; and all plantation hardwood harvests. In future submissions, *afforestation/reforestation* will include HWP derived from harvests from all hardwood plantations from the year 2000 onwards.

Consistent with decision 2/CMP.7, only HWP sourced from domestic forests are considered and estimates are reported according to 3 broad HWP pools: Paper; Sawn wood; and Wood based panels. Accordingly, the 5 pool structure of HWP model used for the UNFCCC inventory is aggregated in the following way for the purposes of reporting:

- Paper and paper-board – pool 1 (Very short term paper and paper products);
- Sawn wood – pool 4 and pool 5 (long and very long term products); and,
- Wood based panels – pool 2 and pool 3 (short and medium term products).

Emissions from consumption of fuelwood are estimated using the same methodology described in Chapter 6.5.4. It has been estimated that 19 per cent of emissions from consumption of wood and wood-waste is attributable to *forest management* lands.

The methods used to estimate carbon stock change and emissions for pre-1990 plantations are the same as those described in Chapter 6.4.2.

11.6.2.2 Data

The same data sources are used for *forest management* as for *forest land remaining forest land*, as detailed in Chapter 6.4.1.1, Appendix 6.A and 6.G.

11.6.2.3 Start year

Estimation of net emissions is undertaken from 1970.

11.6.2.4 Carbon pools

FullCAM estimates emissions from soil as a result of an estimation process involving all on-site carbon pools (living biomass, dead organic matter and soil) for plantations.

For native forests subject to harvesting the soil carbon pool is not estimated. A literature review undertaken by England et al. (2014) concluded that there is insufficient evidence from empirical and modelling studies to conclude whether harvesting causes soil carbon stocks to substantially deviate from an equilibrium range over the long term in Australian native forests.

11.6.3 Natural Disturbances

In Australia, wildfire is the most widespread and frequent natural disturbance event which causes significant losses of carbon stock to the atmosphere.⁴ Other natural disturbances include drought, storm damage, tropical cyclones, and pests and pathogens. In Western and South Australia, for example, *Phytophthora* root rot is one of the most serious diseases threatening native vegetation in the higher rainfall areas. In other cases, certain species are often more susceptible to dieback events than others reflecting competitive and adaptive processes amongst plants as they respond to changes in environmental conditions.

Decision 2.CMP/7 outlines rules for the reporting of natural disturbances in national inventories (the natural disturbances provision).⁵ The natural disturbances provision is aimed at managing the risk of substantial emissions from events beyond the control of a party that would dominate all other emission sources in the national inventory for a short reporting period like the second commitment period under the KP.

In managing these risks, country specific approaches to the natural disturbance provision may be implemented as long as the key principle *that the implementation of the approach is consistent with an expectation that net credits or net debits generated under the treatment of disturbances is zero* (decision 2/CMP.7, annex, paragraph 33 (a)) is maintained.

The natural disturbance provision has been applied to the estimates of emissions from *forest management*.

11.6.3.1 Monitoring system for wildfires

A monitoring system based on the Advanced Very High Resolution Radiometer (AVHRR) has been implemented to identify and map natural disturbance impacts due to wildfire on *forest management* lands. The new system has been designed to comply with the following safeguard mechanisms prescribed under decision 2/CMP.7, which relate to:

- (a) the use of geolocated time series wildfire activity data,
- (b) coverage of all *forest management* lands,
- (c) the ability to monitor if there is a permanent land use change on those lands following a wildfire event

⁴ Natural disturbances are defined in decision 2/CMP.7 as: *Non-anthropogenic events or non-anthropogenic circumstances. For the purposes of this decision, these events or circumstances are those that cause significant emissions in forests and are beyond the control of, and not materially influenced by, a Party. These may include wildfires, insect and disease infestations, extreme weather events and/or geological disturbances, beyond the control of, and not materially influenced by, a Party. These exclude harvesting and prescribed burning.*

⁵ Annex to decision 2/CMP.7, paragraph 33.

during the commitment period,

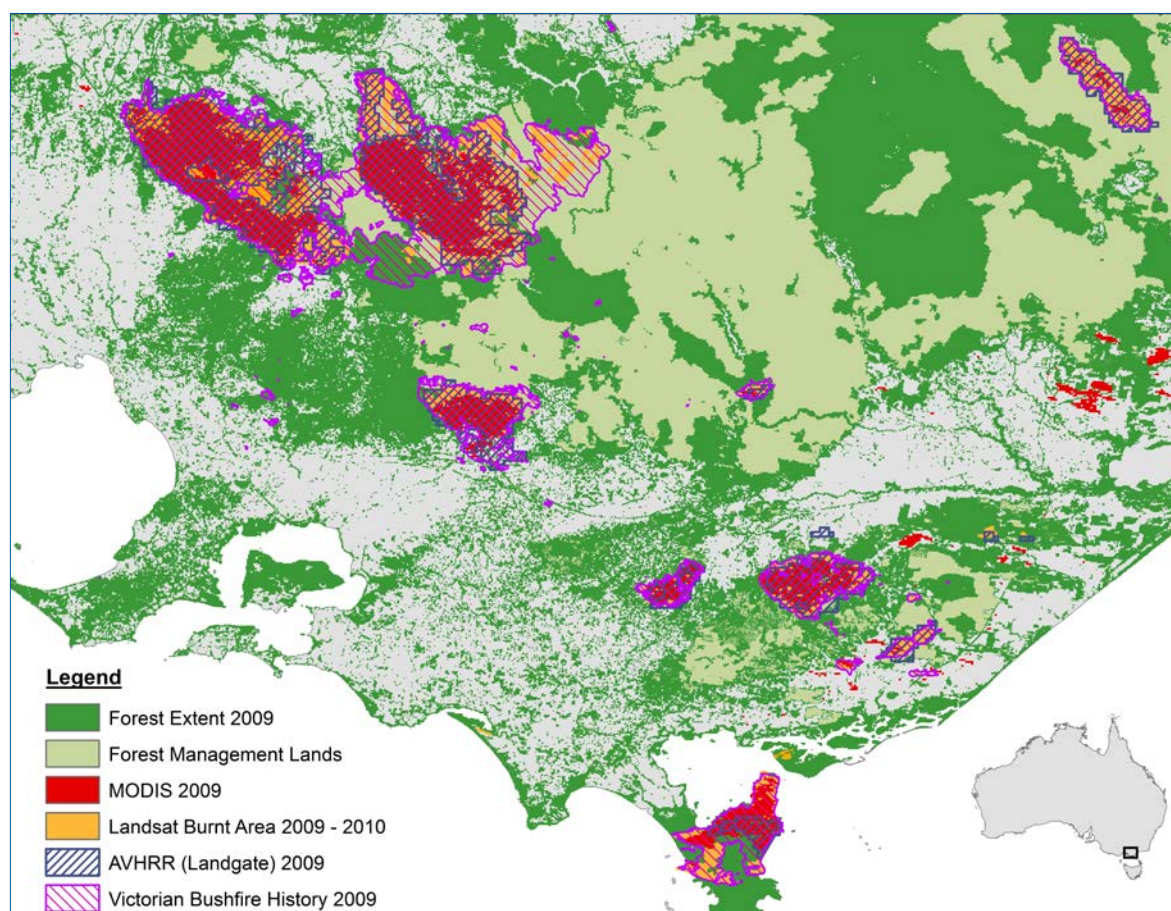
- (d) the exclusion of emissions associated with salvage logging from the accounting,
- (e) identification of lands where the natural disturbance is followed by another disturbance event, in order to avoid double counting, and
- (f) when using remote sensing data, a Party needs to identify the temporal, and spatial resolutions, calibration and validation of wildfire datasets using complementary ancillary and/or ground truth data.

The AVHRR burnt area product produced by the Western Australian Land Authority (Landgate), is tailored to Australian conditions and based on the visual interpretation of fire areas by experienced operators. The data was assessed in Royal Melbourne Institute of Technology (RMIT) 2014, and compared with a range of alternative datasets, and was found to be the most suitable and highest quality time series data available (Figure 11.3).

The datasets considered by the RMIT included:

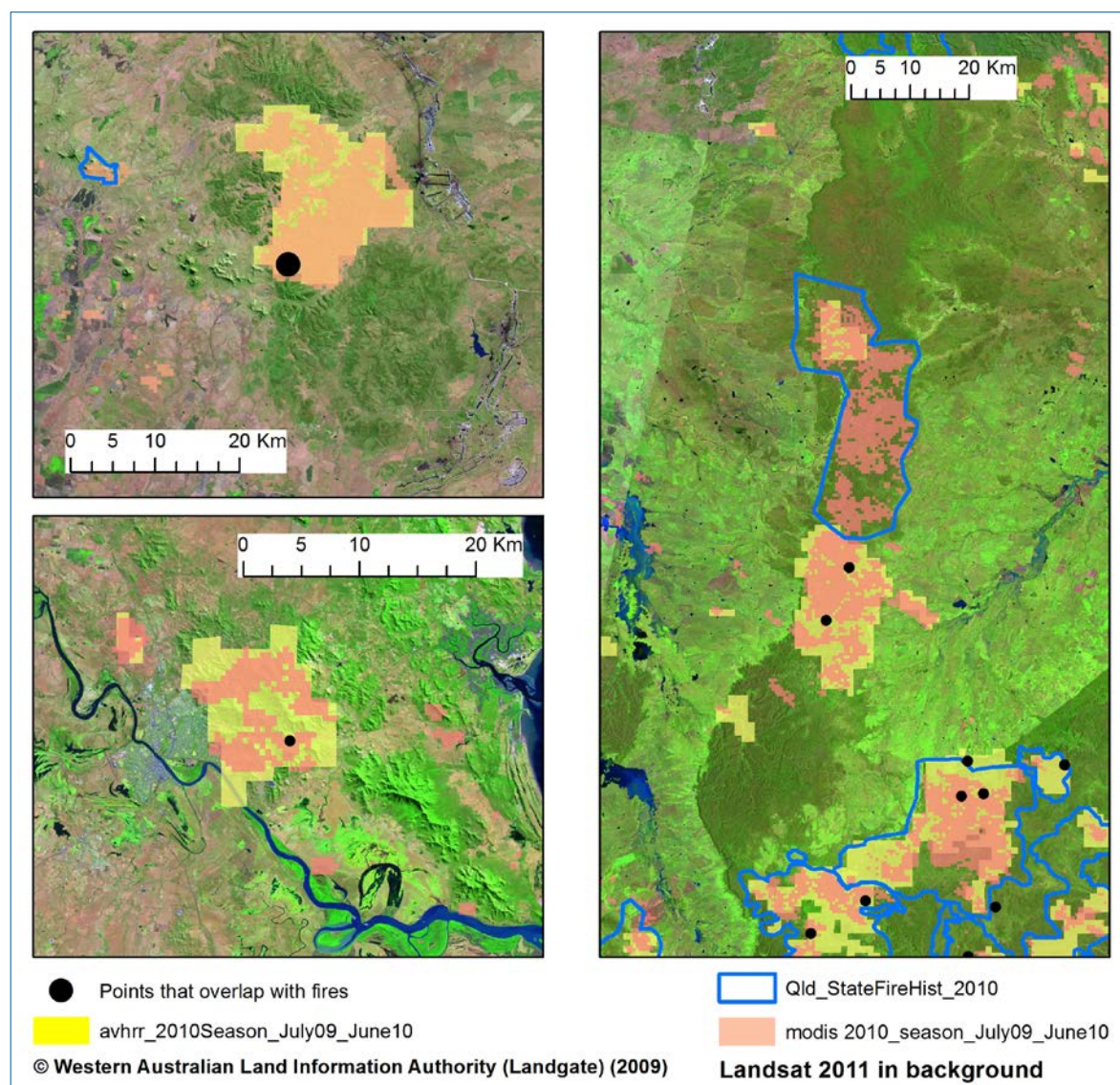
1. Monthly AVHRR burnt area products (1990 to 2014), obtained from the Western Australian Land Information Authority (Landgate);
2. Monthly MODIS burnt area 500m products (2000 to 2013), obtained from the global database maintained by the University of Maryland, USA;
3. Limited coverage of wildfire data from the Landsat series of satellites; and
4. Reference bushfire history data supplied by state agencies.

Figure 11.3: Comparison of four bushfire datasets over a portion of multiple-use public forests in Victoria.



The overall quality of the post-2000 AVHRR burnt area products had a low commission error (5.4%) which indicates that 94.6 % of the wildfire detected in the Landgate AVHRR burnt area product were correctly classified (Figure 11.4). The omission error was around 11% after accounting for the undetected low-intensity prescribed burns (22%) and smaller fires below the minimum mapping unit (9%) which the 1km resolution AVHRR optical sensors were not expected to detect.

Figure 11.4: Validation of MODIS burnt area (orange), AVHRR burnt area (yellow) using the fire history data from Queensland (blue) derived from Landsat satellites. Black dots represent sampling points



Prescribed burns are estimated on the basis of State agency reports, as these fire types are hard to detect from coarser resolution satellite missions, such as the AVHRR sensor.

In addition to the calculation of annual wildfire extent, the system has been designed to monitor post-fire regrowth to ensure that there is no permanent land use change following a fire event (see Section 1.2.3.1). The system also monitors for incidences of multiple fires affecting the same lands within the commitment period (Figure 11.5, Figure 11.6) to avoid double-counting.

Figure 11.5: AVHRR based burnt area frequency for the period from 1988 to 2014

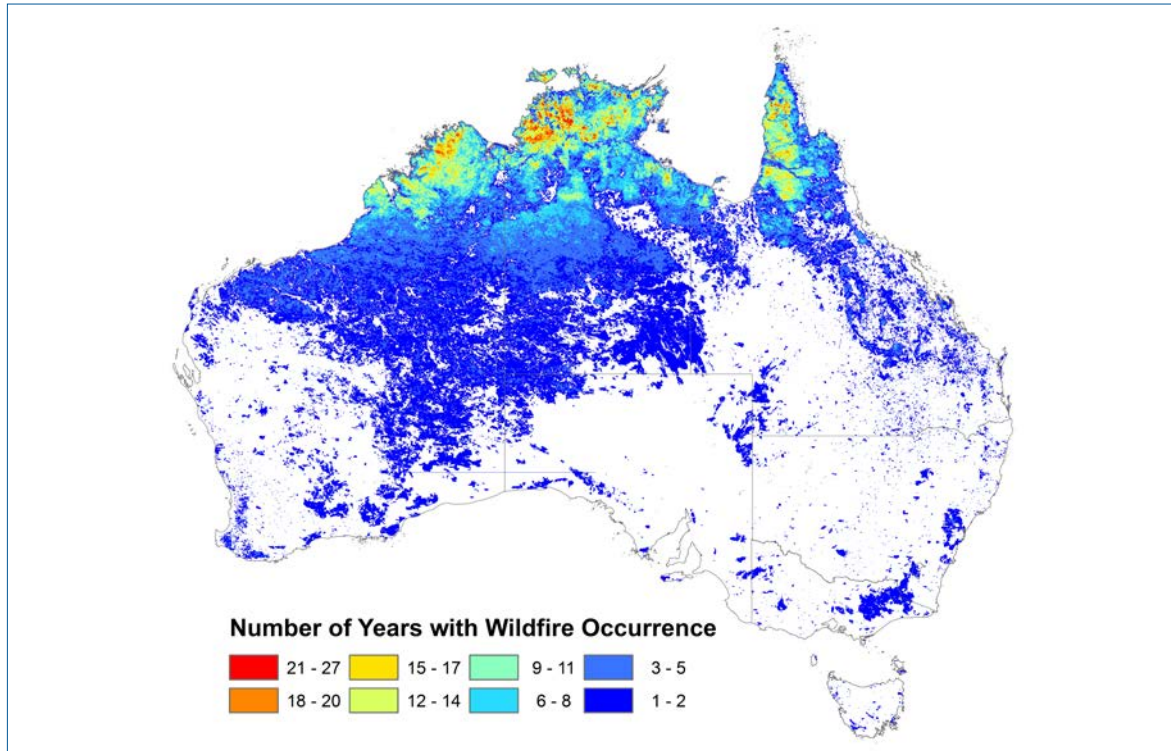
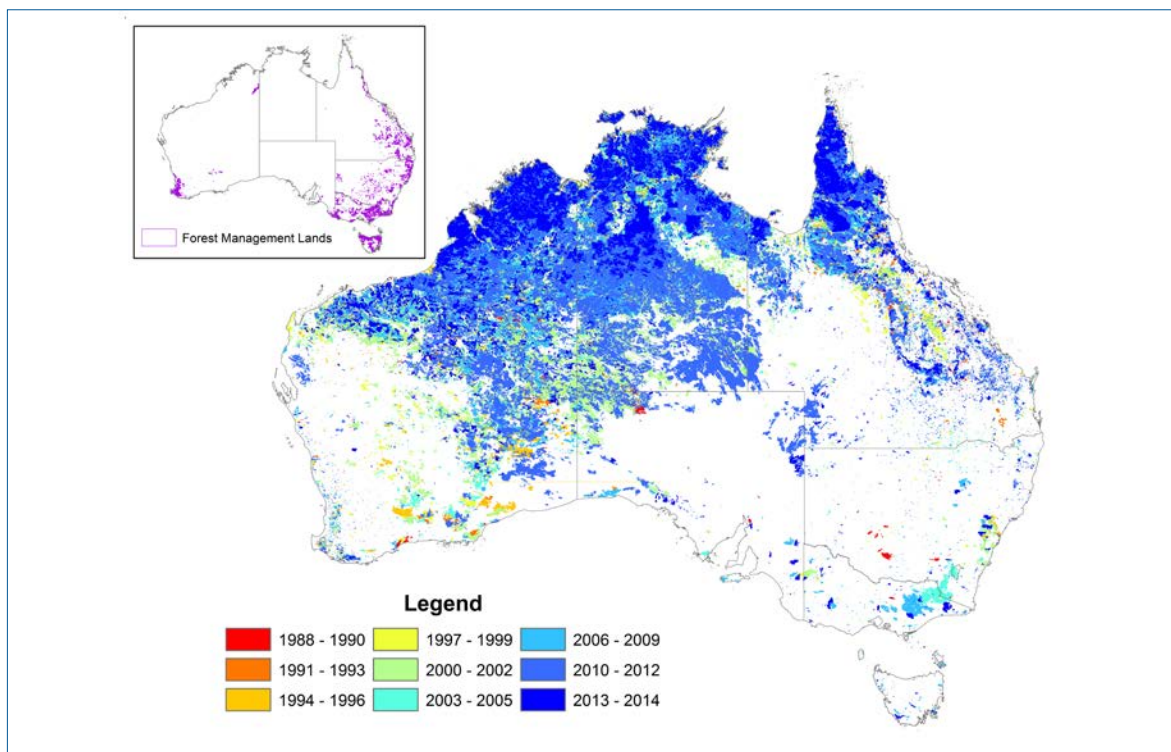


Figure 11.6: Year since last burn for the period from 1988 to 2014. Inset map shows the distribution of *forest management* Lands in Australia



The system will be subject to regular enhancements over time as remote sensing and data processing technologies evolve and as new information becomes available.

11.6.3.2 Method to estimate natural disturbance emissions and subsequent removals on *forest management* lands

The methodology used by Australia to estimate wildfire emissions and subsequent removals on *forest management* lands is documented in Section 6.5.3.1, and is the same as the methodology applied to the *Forest land remaining Forest land* classification.

11.6.3.3 The Background Level and the margin

Australia has calculated a background level and margin using the IPCC default method (see IPCC 2014, page 2.48-2.50). The background level and margin are presented in Table 11.16.

Table 11.16: Components of Australia's background level and margin

Parameter	Value
Calibration period	2000-2012
Method used	IPCC default
Background level	2.63 Mt CO ₂ -e
Margin	3.35 Mt CO ₂ -e
Background level plus margin	5.98 Mt CO ₂ -e
Number of excluded years	Four
Excluded years	2003, 2007, 2009, 2010

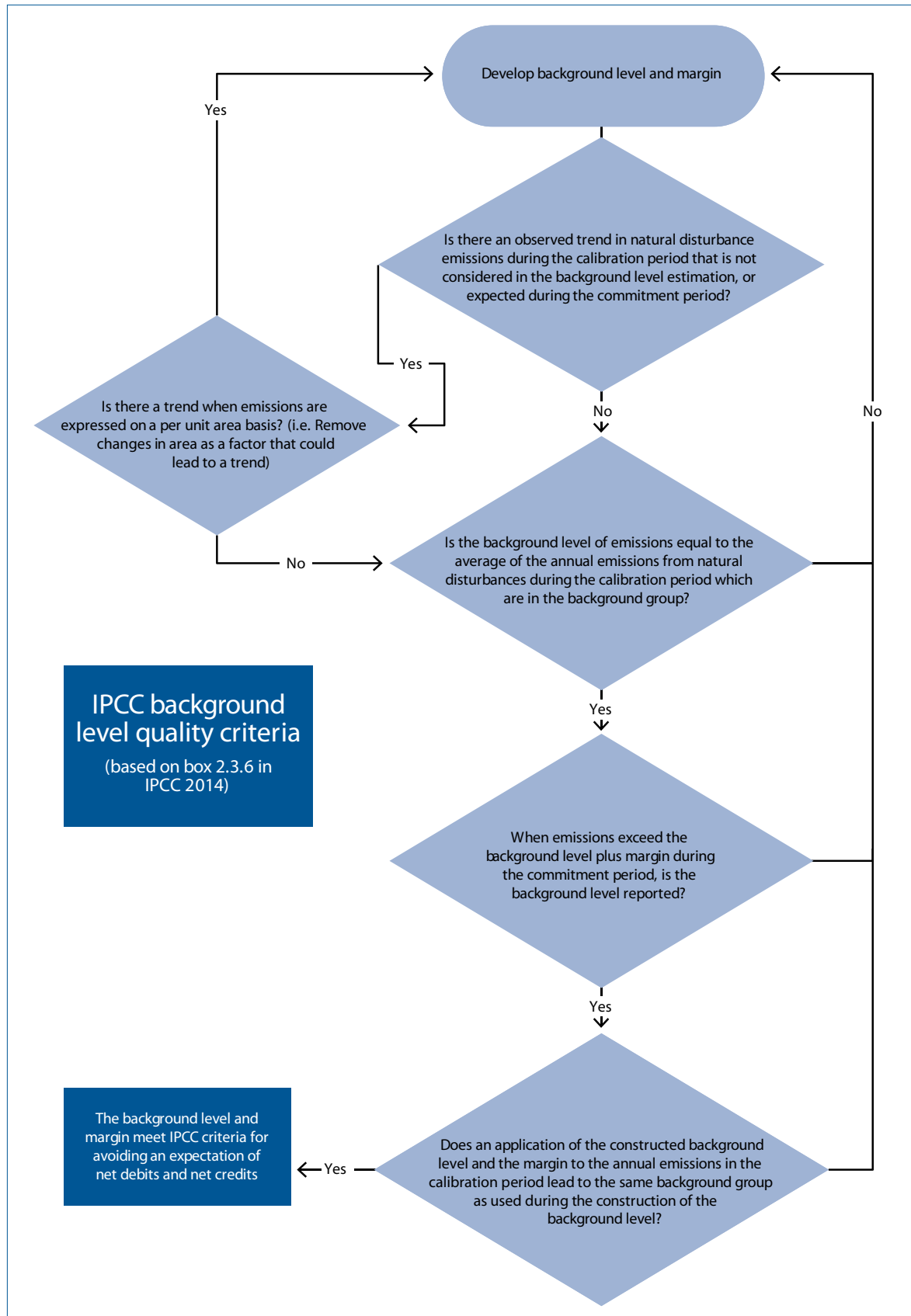
IPCC quality criteria for the construction of the background level plus margin

Four criteria for determining whether the data used to construct the background level and margin could result in an expectation net credits or net debits are set out in Box 2.3.6 of IPCC (2014) page 2.50:

1. Trend – If there is a trend in natural disturbance emissions during the calibration period that is not considered in the background level estimation, or expected during the commitment period, then this could create an expectation of net debits or net credits.
2. Balance – The background level of emissions is equal to the average of the annual emissions from natural disturbances during the calibration period which are in the background group.
3. Reporting the background level – Any emission from natural disturbances during the commitment period that falls into the background group is not separately excluded from accounting. During the commitment period, emissions are only excluded from accounting when the annual emissions are greater than the background level plus the margin. When this occurs, only those emissions that are greater than the background level are excluded.
4. Validation – A test application of the constructed background level and the margin to the annual emissions in the calibration period leads to the same background group as used during the construction of the background level.

The procedure shown in the decision tree below (Figure 11.7) was implemented to ensure that the specified background level and margin meet these four criteria.

Figure 11.7: Decision tree to support the development of a natural disturbance background level that is consistent with the IPCC background level quality criteria



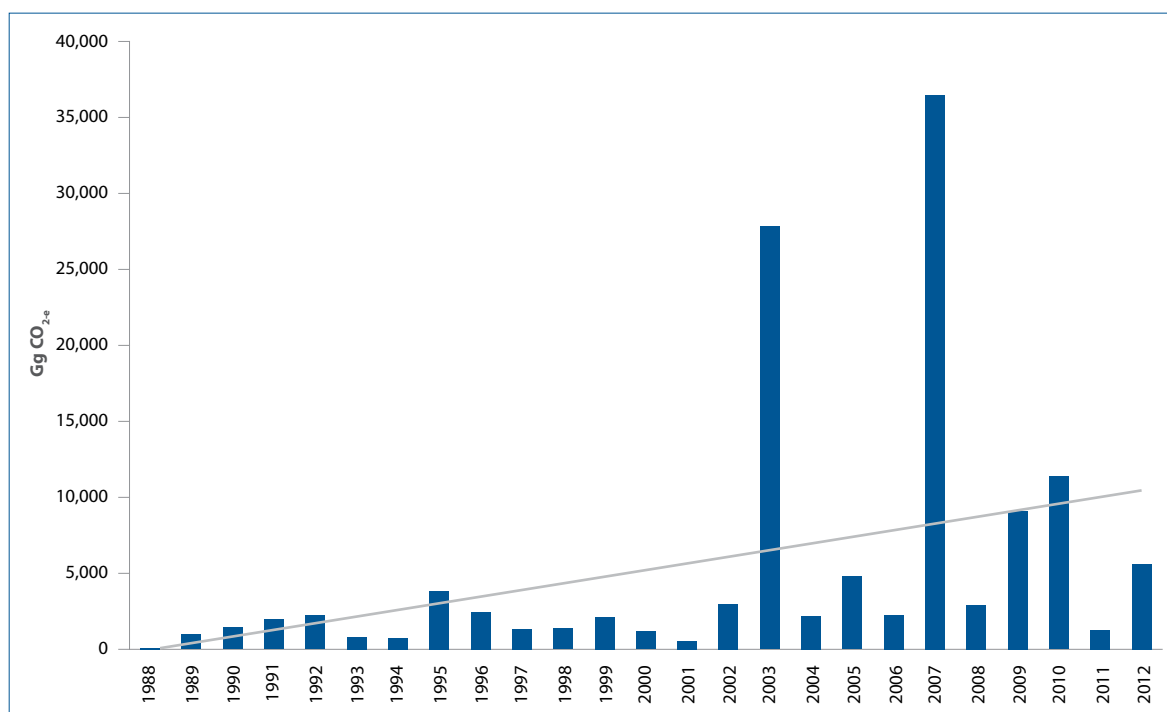
Trend criterion

Decision 2/CMP.7 requires parties to use data from 1990-2009 – known as the calibration period – for the purpose of developing the background level and margin. An exception to this requirement is if this would lead to the expectation of the creation of net credits or net debits from the operation of the natural disturbance provision.

An important condition that must be satisfied is that there is no observable trend in natural disturbance emissions over the available time series. As shown in Figure 11.8, this condition is not satisfied by the data on wildfire in Australia. Based on this trend assessment, the period 1988-1999 was excluded from the calibration group.

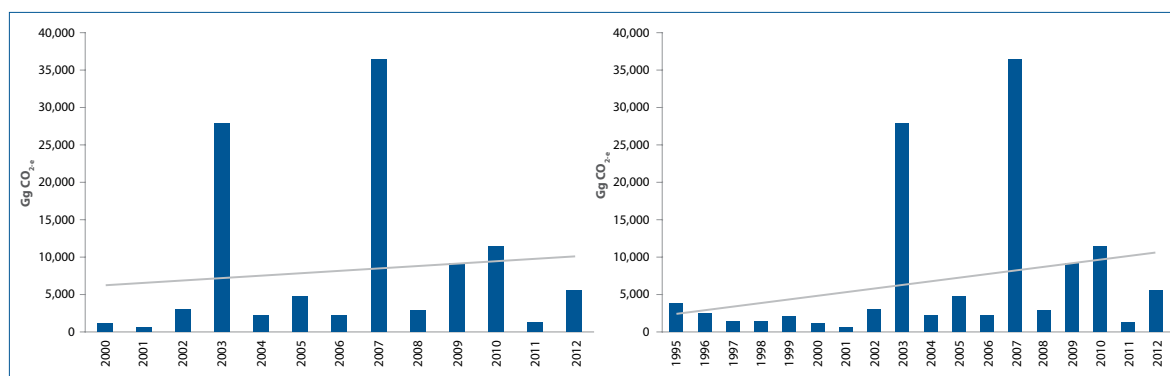
The period chosen to establish the dataset that underpins the estimation of the Background level is 2000-2012. This selected calibration group was then tested against the three IPCC quality criteria.

Figure 11.8: Wildfire burnt CO₂ emissions on forest management land and trend line, excluding CO₂ emissions associated with salvage logging



As shown in Figure 11.9 the slope of the trend line for the selected calibration period (2000-2012) is shallower than the slope of a longer calibration period (e.g. 1995-2012) (Figure 1.9).

Figure 11.9: Comparison of emissions trend across the selected calibration period and of a longer calibration period (1995-2012)



If the trend lines in Figure 11.9 are extended over the period 2013-2020 the increase in the trend in emissions for the selected calibration period is 1,566 Gg CO₂-e while over a longer period, for example 1995-2012, the increase in the trend of emissions is 3,397 Gg CO₂-e.

While there remains a trend in the selected calibration period the period 2000-2012 was selected to balance the need to limit the trend in emissions against having a calibration period that was too short.

Balance criterion

To meet the balance criterion, the calculated background level must equal the average of the annual emissions from natural disturbances during the calibration period which are in the background group.

The performance of the calculated background level against the balance criterion is shown in Table 11.17, which shows the calculated background level meets the balance criterion.

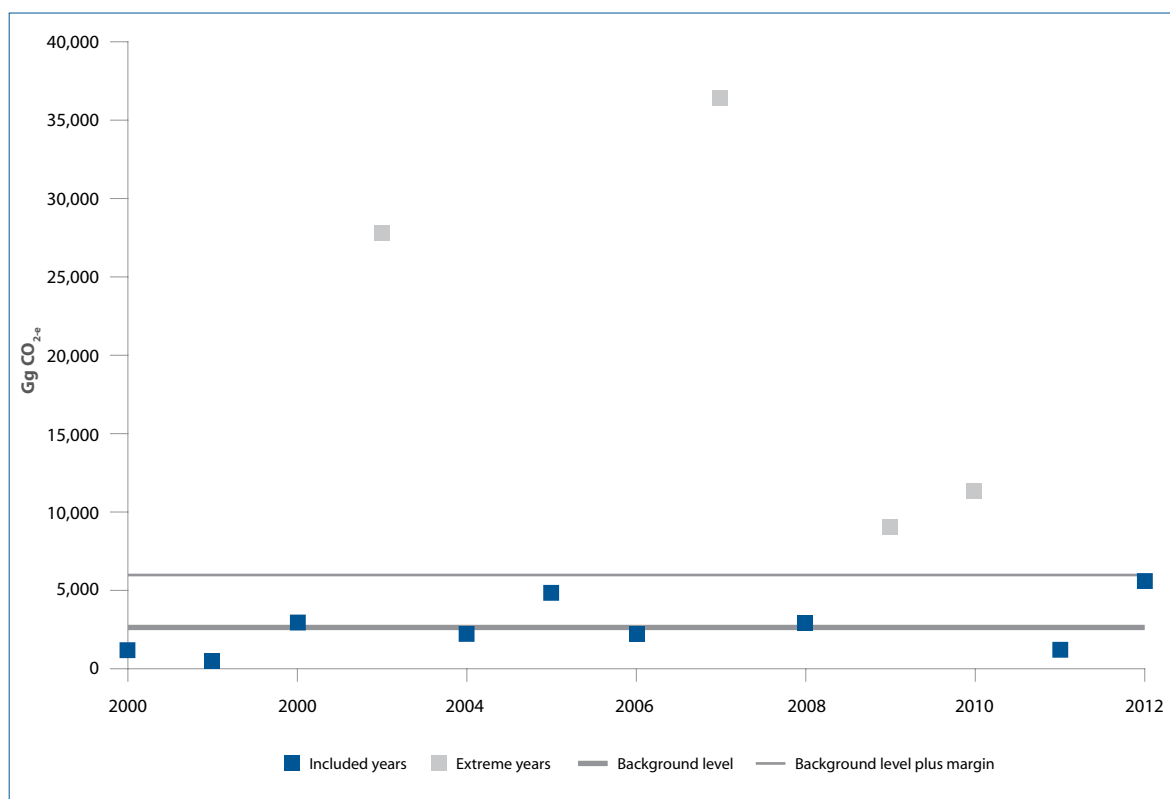
Table 11.17: Test of the balance criterion for a background level based on the 2000-2012 calibration group

Years included in background group	Wildfire emissions Mt CO ₂ -e
2000	1.18
2001	0.55
2002	2.96
2004	2.18
2005	4.79
2006	2.25
2008	2.93
2011	1.26
2012	5.61
Average of background group	2.63
Background level	2.63
Difference	0.00
Balance criterion met?	Yes

Validation criterion

To satisfy the validation criterion, the emissions in any of the background group years should not exceed the background level plus margin. As shown in Figure 11.10, emissions in the background group years do not exceed the background level plus margin. The validation criterion has been met.

Figure 11.10: Background level and background level plus margin based on the 2000-2012 calibration data set.

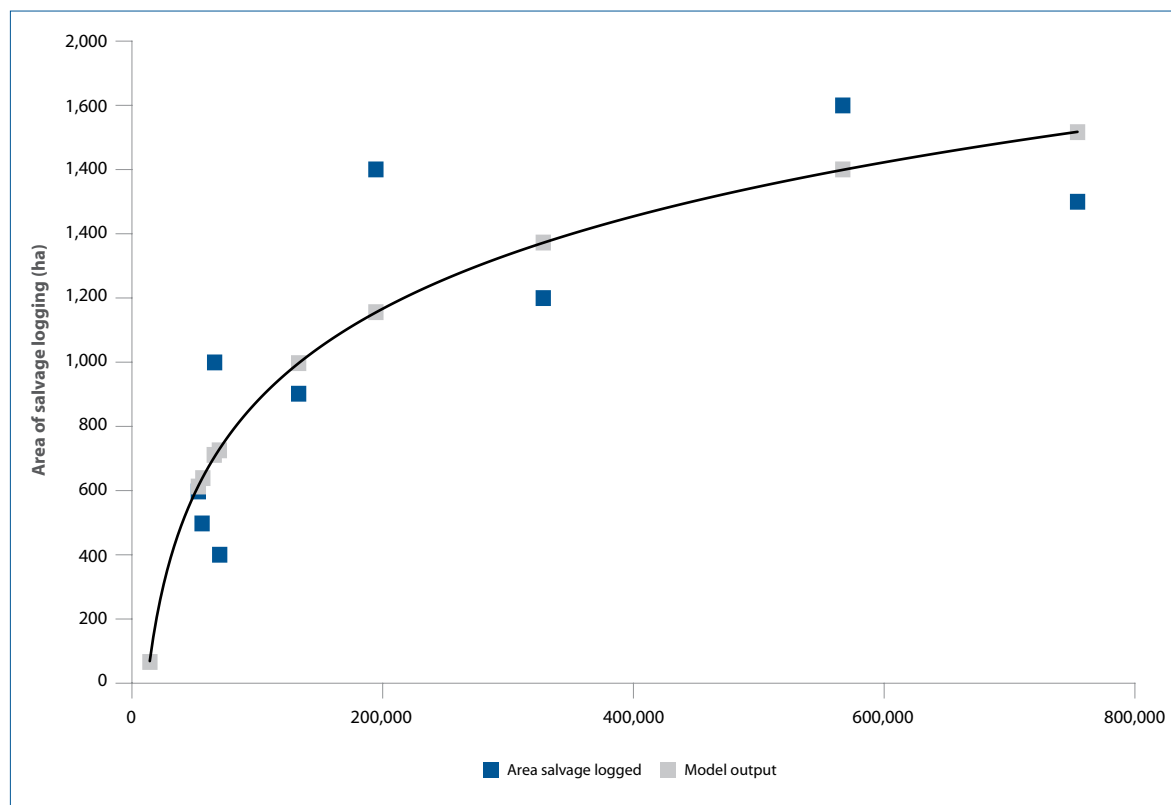


11.6.3.4 Ensuring that emissions caused by salvage logging on land subject to natural disturbance are transparently reported

Estimates of emissions from salvage logging are based on regression model using a time-series of salvage logging in multiple-use public forests for the period 2001–02 to 2010–11 published in Australia’s State of the Forests Report 2013 (MPIG, 2013 Table 2.5). The model outputs an estimate of the area subject to salvage logging based on the area burnt by wildfire in the multiple-use public forests (based on the Department’s AVHRR data). A strong statistical relationship was found between the area burnt by wildfire in the multiple-use public forests and the area of salvage logging was lagged by one year (R^2 0.81) (Figure 11.11).

The regression model built from this relationship enables the consistent estimation of the area of salvage logging based on the area burnt within multiple-use public forests. This model can be used to support the transparent reporting of emissions associated with salvage logging on land that is subject to natural disturbance.

Figure 11.11: Relationship between wildfire area burnt and the area of salvage logging



Demonstration that the expectation of net credits/net debits is zero.

According to IPCC (2014) (section 2.3.9.6, step 5) it is *good practice* for parties to ensure that the method applied to the development of the background level and margin does not lead to the expectation of net credits or net debits.

The Department of the Environment monitors the implementation of the background level and margin to ensure that there is no expectation of net debits or net credits associated with the implementation of the natural disturbance provision. If such a situation arises a technical correction will be applied to the FMRL.

11.6.3.5 Information that natural disturbance events were beyond the control of the party (IPCC 2014, page 2.36)

In Australia, wildfires threaten life and property, and are addressed in disaster response plans and management arrangements in each state and territory. Common frameworks for national, state and territory fire management policies include: reducing the likelihood of fires occurring, for example through fuel reduction burning and fire bans; managing or controlling the fire during its occurrence; monitoring programs and early warning systems; and fire fighting operations. In addition to such disaster management policies, there is also a significant research effort into understanding and better managing wildfires, and following many significant fire events, inquests or enquiries are held to assess the disaster response and potential for improvement.

There are fire management policies and plans in place at the national and the state and territory level to control for the risks, events and consequence of wildfire to the extent that this is possible. These documents set-out frameworks for:

- Reducing the likelihood of a wildfire occurring, for example, through the use of prescribed burning;

- Managing or controlling the disturbance during its occurrence;
- Monitoring programs and early warning systems; and
- Fire fighting operations.

The implementation of plans and strategies to avoid and minimise risks to life and property from wildfires is documented in the following section.

National level

The National Bushfire Management Policy Statement for Forests and Rangelands (FFMG 2014)⁶ outlines Australian, state and territory government objectives and policies for the management of landscape-level fire in Australia's forests and rangelands. The statement was developed by the Forest Fire Management Group, a national body within the ministerial council structure, with the role of providing information to governments on major forest fire-related issues, policies and practices affecting land management. The Australasian Fire and Emergencies Authorities Council is the national peak organisation that provides advice on a range of policies and standards. Research on bushfires is performed by a number of organisations, including:

- the Bushfire Cooperative Research Centre, which brings together experts from universities;
- the Commonwealth Scientific and Industrial Research Organisation (CSIRO);
- other Australian, state and territory government organisations, and;
- the private sector for long-term programs of collaborative research.

The national Bureau of Meteorology publishes fire weather warnings and has a role in the declaration of fire bans when weather conditions are conducive to the spread of dangerous bushfires. Warnings are generally issued within 24 hours of the potential onset of hazardous conditions. Warnings are also broadcast on radio and television.

Fire agencies determine Fire Danger Ratings. In most States and Territories, fire agencies declare fire bans based on a range of criteria including forecast weather provided by the Bureau.

The Bureau also incorporates Total Fire Ban Advices into warnings, if one is being enforced at the time of issue, and an action statement from local fire authorities detailing areas where the ban is in effect.

Fire Weather Warnings are distributed through the media, fire agencies and other key emergency service organisations. Warnings are normally issued in the afternoon for the following day so to be available for evening television and radio news broadcasts. Warnings are renewed at regular intervals and generally at the same time major forecasts are issued. However, warnings may be issued or amended and reissued at any time if a need is identified. If there is a Fire Weather Warning current, the Bureau will mention this in State, Territory and District weather forecasts for that area.

In each State the issue of a Fire Weather Warning has different impacts on restrictions for lighting fires.

The Bureau of Meteorology does not have the power to declare a Total Fire Ban. This responsibility resides with designated fire agencies in each State and Territory. However, in South Australia, Northern Territory, Victoria, New South Wales and Tasmania, the Bureau does issue Total Fire Ban Advices to assist publicising and distributing the message. The Bureau also includes information about the existence of current fire bans in weather forecasts and warnings.

The areas covered by fire bans do not align with Bureau forecast districts in New South Wales, Tasmania and Northern Territory.

⁶ https://www.semc.wa.gov.au/riskmanagement/Documents/NationalBushfireManagementPolicy_2014.pdf

State and territory level

Each state and territory has published a document which sets the framework for the management of bushfires. These plans include information on the use of public information campaigns and requirements around the declaration and publication of fire bans and fire danger ratings during fire seasons. In Queensland the documents are published for a number of regions within the state, rather than at the state level.

New South Wales

The aim of the State Bush Fire plan is to set out the arrangements for preparedness, prevention, mitigation, response to and recovery from bush fire events by combat, participating and support agencies in NSW.

This plan describes the arrangements for the control and coordination of the response to Class 2 and 3 bush and grass fires, including those managed under the provisions of section 44 of the Rural Fires Act 1997 (RF Act), and the provisions for emergency warnings at all classes of fires.

These arrangements ensure that the two combat agencies, New South Wales Rural Fire Service (NSW RFS) and Fire & Rescue NSW (FRNSW), are able to manage bush and grass fires, utilising assistance from the other fire fighting authorities being the National Park & Wildlife Service (NPWS) and Forestry Corporation NSW (FCNSW).

The NSW State Bush Fire plan is available here: <http://www.emergency.nsw.gov.au/content.php/552.html>

Victoria

Victoria's State Bushfire Plan provides an overarching view of responsibilities of agencies, government and communities in bushfire management.

The first version of the State Bushfire Plan was developed in 2012 in conjunction with the Country Fire Authority, the Metropolitan Fire Brigade, the Department of Environment and Primary Industries and the Fire Services Commissioner.

The second version of the State Bushfire Plan was produced in 2014, with updates to reflect the changes in Victorian emergency management legislation and the emergency management sector.

The plan reflects an integrated approach and shared responsibility for bushfire management between government, agencies, business, communities and individuals.

Although intended as a reference document for fire and emergency management agencies, the State Bushfire Plan will be of equal interest to anyone who works or volunteers in bushfire management.

The State Bushfire Plan is a sub-plan of the State Emergency Response Plan (SERP), found in the Emergency Management Manual of Victoria (EMMV), the principal document for guiding the State's emergency management arrangements.

Victoria's State Bushfire Plan is available here:
<http://www.emv.vic.gov.au/plans/state-bushfire-plan/>

Queensland

In Queensland, fire management policies and plans are developed at regional rather than at the state level. The Queensland government provides an overview of the approach to disaster management in Queensland here: <http://www.disaster.qld.gov.au/>

Western Australia

Western Australia has developed a series of State Emergency Management Plans (Westplans) including an integrated urban and bushfire management plan. The plan is available here:

<https://www.semc.wa.gov.au/WA%20State%20Emergency%20Management%20Arrangements/Westplan%20Fire%20September%202013.pdf>

South Australia

The South Australian State Emergency Management Plan is available here:

http://www.safecom.sa.gov.au/site/emergency_management/emergency_management_arrangements/state_emergency_management_arrangements.jsp

Tasmania

Tasmania's state fire protection plan is available here:

http://www.fire.tas.gov.au/userfiles/stuartp/file/Publications/StateFireProtectionPlanVersion2_2.pdf

Northern Territory

Bushfire management and control in the Northern Territory is managed through the framework provided by the Regulations under the Bushfires Act (1980). The regulations are available here:

<http://notes.nt.gov.au/dcm/legislat/legislat.nsf/64117dddb0f0b89f482561cf0017e56f/a4f6a31080150e5569257bda0003f823?OpenDocument>

Australian Capital Territory

The Standard Operating Procedures of the ACT Rural Fire Services provide the framework for the management of bushfires in the ACT. The Standard Operating Procedures are available here:

<http://esa.act.gov.au/actrfs/publication-and-links/standard-operating-procedures/>

11.6.3.6 Information to identify lands where the natural disturbance is followed by another disturbance event, in order to avoid double counting (IPCC 2014, page 2.45)

Natural disturbance events are monitored using data derived from the AVHRR sensor as described in section 1.6.4.1. The system established to monitor, track and archive the AVHRR burnt area data detects incidences of burnt areas on the same unit of land within the commitment period.

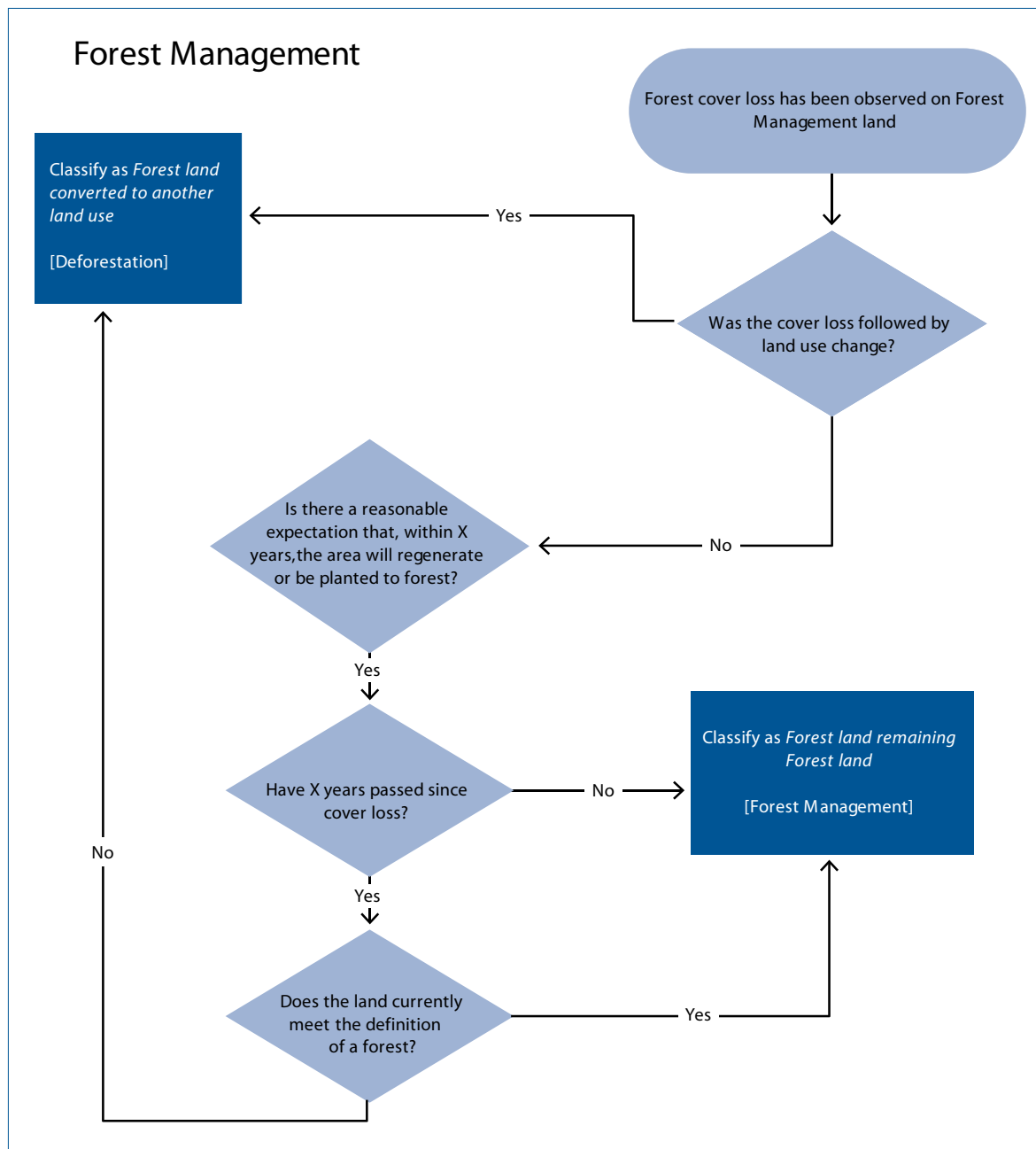
The method for estimating removals during the recovery from a natural disturbance event is documented in volume 2, section 6.5.3.1. According to this method, the biomass consumed during a wildfire in temperate forests recovers over a five year period following the fire. If a single unit of land was already affected by a wildfire within the preceeding five years, some portion of the emissions on this land could be considered as double counted if the fuel load was assumed to be at an equilibrium level when the second wildfire occurred. Where repeat burning within five years is observed (before fuel loads have recovered) an estimate of the fuel load present is made by dividing the equilibrium fuel load by five and multiplying by the number of years since last burnt in order to avoid double counting.

In 2014, around 0.3 per cent of *forest management* land was observed to experience a repeat fire within the 5 years to 2013.

11.6.3.7 Information to identify lands where land use change has occurred after a natural disturbance (IPCC 2014, page 2.45)

All forest land is monitored for harvesting and deforestation events. *Forest management* land is monitored for 12 years following forest cover loss events (due to harvesting, fire and other disturbances) to determine if land use change has occurred (section 1.2.3.1) consistent with the requirements for determining if land is subject to *deforestation* specified in Figure 2.6.1 of IPCC (2014) (Figure 11.12).

Figure 11.12: Monitoring and classification of *forest management* land following a forest cover loss event



11.6.3.8 Information on efforts to rehabilitate the land subject to natural disturbances (IPCC 2014, page 2.53)

The need for rehabilitation of Australia's native forests following natural disturbance is dependent upon the nature of the disturbance. Australia's native forest are generally dominated by fire tolerant species. The principal fire tolerant responses in forest tree species are summarised Table 11.18⁷. Some species however, for example Mountain Ash (*Eucalyptus regnans*) and Alpine Ash (*Eucalyptus delegatensis*) are vulnerable to frequent fires as the plants are unable to reach maturity and produce sufficient seed before the next fire.

In the case of Alpine Ash there are examples of the need for re-seeding following fire to ensure the rehabilitation of the forest⁸. Table 11.18: Adaptation of Australia forest genera to fire

Adaptation to enable natural regeneration after fire	Forest genera
Stimulation of seed release from woody capsules by heat and desiccation	<i>Casuarina</i> , <i>Hakea</i> , <i>Banksia</i> , <i>Leptospermum</i> and <i>Eucalyptus</i> .
Stimulation of germination of soil-stored seed by fire	<i>Acacia</i>
Stimulation of bud development after fire from lignotubers	<i>Eucalyptus</i>

11.6.4 Forest Management Reference Level Technical Correction

Australia's 2011 FMRL submission (DCCEE, 2011) outlines the methods used for estimating the reference level.

There have been a number of methodological refinements since this reference level was submitted, which include changes to address the subsequently agreed rules for implementing the natural disturbances provision and calculating emissions from harvested wood products (UNFCCC, 2011). There have also been methodological refinements to other methodological elements used in the estimation of emissions from *forest management*.

Methodological consistency between the reference level and the reporting of *forest management* in the national inventory must be demonstrated, including by making technical corrections to the FMRL if necessary.

If there are any recalculations of the historical data used to establish the reference level, a technical correction must be applied.

In order to maintain such methodological consistency, a technical correction has been estimated of 3.6 Mt CO₂-e. This correction incorporates corrections to the sub-categories of *forest management* reporting Table 11.19.

⁷ Atwell, Kriedemann, and Turnbull (1999) *Plants in Action*, Macmillan Education Australia, Melbourne.

⁸ <http://archive.premier.vic.gov.au/2014/media-centre/media-releases/7162-helicopters-sowing-alpine-ash-forest-following-harrietteville-fire.html>

Table 11.19: Technical correction by sub-category – summary

2011 FMRL (Mt CO ₂ -e)					
Included natural disturbances emissions	Pre-1990 Plantations	Multiple Use Forests**	Private Native Harvest ⁺	Harvested Wood Products	Total
8.7	0.3	-9.1	9.6	-4.7	4.7
Corrected FMRL after methodological refinements (FMRL _{corr}) (Mt CO ₂ -e)					
Background Level of natural disturbance emissions	Pre-1990 Plantations	Multiple Use Forests**	Private Native Harvest ⁺	Harvested Wood Products	Total
2.6	2.6	-6.9	6.5	-3.7	1.1
Required Technical Correction (Mt CO ₂ -e)					
-6.1	2.4	2.2	-3.1	1.0	-3.6

* including prescribed burning emissions

+ including fuelwood collection and burning

Relevant criteria under IPCC (2014) (page 2.101) that trigger the requirement to report a technical correction include:

1. The method used to report emissions and removals from *forest management* changed after the adoption of FMRL
2. Any of the following methodological elements used to establish the FMRL (as reported in the FMRL submission) changed after the adoption of the FMRL
 - a. Pools and gases
 - b. Area under *forest management*
 - c. Historical inventory data Forest characteristics and related management
 - d. Historical harvesting rates
 - e. Climate data assumed by models for projecting FMRL
 - f. Harvested Wood Products (including data or methods)
 - g. Natural Disturbances.

These criteria have been matched against the different aspects of technical correction in Table 11.20 below.

Table 11.20: Elements of technical correction and cross-reference with IPCC good practice guidance

Component of forest management Correction	Technical Correction (Mt CO ₂ e)	Factors leading to correction	IPCC (2013) Guidance Criteria	Reason for methodological change or methodological refinement (References to 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol 1)
Private Native Harvest				
Calendar year Reporting	-3.09	<ul style="list-style-type: none"> Cumulative correction Activity data converted from financial years to calendar years, consistent with broader LULUCF inventory reporting 	Criteria 2.b recalculation of area under FM, and 2.e recalculation of historical harvest rates	<ul style="list-style-type: none"> Recalculation of activity data in order to ensure consistency with reporting of other Article 3.3 and 3.4 activities and <i>Forest land remaining forest land</i> (in accordance with <i>good practice</i>: IPCC (2014) Ch 2.7.5.1 (construction of FMRL) and Ch 2.7.5.2 (Methodological consistency between FMRL and reporting for FM)
Combined	-2.77	(<i>Tasmania & other states</i>)		
Tasmanian harvested private native forest	-0.80	<ul style="list-style-type: none"> Changed time series from 1990-2020 to 1970-2020 New activity data (ABARES) 	Criteria 2.b recalculation of area under FM, and 2.e recalculation of historical harvest rates	<ul style="list-style-type: none"> Methodological refinement to utilise new activity data (in accordance with <i>good practice</i>: Ch 5.2.1 Recalculations due to methodological changes and refinements) New data ensures time series consistency by using same method and data source for all years and consistency of estimation method on a national basis including for multiple-use public forests and UNFCCC Harvested Native Forests Extrapolation of pre-1990 harvesting allows comparison with post-1990 emissions trend to ensure that only real changes in activity data are reflected in estimates
Other States (NSW, Qld, WA)	-1.33	<ul style="list-style-type: none"> New modelling method (now FullCAM) Time series and activity data now consistent with TAS (1970-2020) 	Criteria 1. change of GHG reporting method and Criteria 2.b recalculation of area under FM, and 2.e recalculation of historical harvest rates	<ul style="list-style-type: none"> Methodological refinement to utilise new activity data (in accordance with <i>good practice</i>: Ch 5.2.1 Recalculations due to methodological changes and refinements) New data ensures consistency of estimation method on a national basis including for multiple-use public forests and UNFCCC Harvested Native Forests and time series consistency by using same method and data source for all years

Component of forest management Correction	Technical Correction (Mt CO ₂ e)	Factors leading to correction	IPCC (2013) Guidance Criteria	Reason for methodological change or methodological refinement (References to 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol 1)
Multiple-use public forests				
Calendar year Reporting	2.17	<ul style="list-style-type: none"> Cumulative correction Activity data converted from financial years to calendar years, consistent with broader LULUCF inventory reporting 	Criteria 2.e recalculation of historical harvest rates	<ul style="list-style-type: none"> Recalculation of activity data in order to ensure consistency with reporting of other Article 3.3 and 3.4 activities and <i>Forest land remaining forest land</i> (in accordance with <i>good practice</i>: IPCC (2014) Ch 2.7.5.1 (construction of FMRL) and Ch 2.7.5.2 (Methodological consistency between FMRL and reporting for FM)
Correction for observed deforestation	2.92	<ul style="list-style-type: none"> <i>Cumulative correction</i> Annual harvesting area and total forest management estate area corrected for observed deforestation Includes projected rates of deforestation during reference level period (2013-2020) (based on historical average) 	Criteria 2.b recalculation of area under FM, and 2.e recalculation of historical harvest rates	<ul style="list-style-type: none"> Implementation of land classification system consistent with Article 3.3 and 3.4 and consistent with <i>good practice</i>: IPCC (2014) Ch 1.3 and 2.7.2 Correction a result of improvements in forest monitoring capabilities enabling identification of deforestation (harvesting that was not observed to re-grow within the defined period) on FM lands Annual harvesting and lands excluded from FM are reported under <i>deforestation</i>
Pre-1990s average harvest rates	4.16	<ul style="list-style-type: none"> <i>Cumulative correction</i> Early '90s average used to project backwards; reflecting an assumption of harvesting occurring on lands listed as conservation reserves as at December 2009 Using new activity data from ABARES AFWPS 	Criteria 2.e recalculation of historical harvest rates	<ul style="list-style-type: none"> Used extrapolation to estimate pre-1990 harvest and improve consistency with post-1990 harvest data (in accordance with Ch 5.3.3.4 using trend extrapolation to resolve data gaps) Ensures that modelled emissions trends reflect only real changes in activity data (post 1990), not model artefact due to technique to resolve data gap in historical activity data

Component of forest management Correction	Technical Correction (Mt CO ₂ e)	Factors leading to correction	IPCC (2013) Guidance Criteria	Reason for methodological change or methodological refinement (References to 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol 1)
Activity Data	0.09	<ul style="list-style-type: none"> Cumulative correction Using new activity data – Australian Forest and Wood Products Statistics by ABARES 	<p>Criteria 2.b recalculation of area under FM, and</p> <p>2.e recalculation of historical harvest rates</p>	<ul style="list-style-type: none"> Methodological refinement to utilise new activity data (in accordance with <i>good practice</i>: Ch 5.2.1 Recalculations due to methodological changes and refinements) New data ensures consistency of estimation method on a national basis including for harvested private native forest and UNFCCC Harvested Native Forests and time series consistency by using same method and data source for all years
Time series change	0.24	<ul style="list-style-type: none"> Cumulative correction multiple-use public forests harvest now modelled for 1970 to 2020. (Prev 1960) Using FMRL raw harvest data 	Criteria 2.e recalculation of historical harvest rates	<ul style="list-style-type: none"> Reduces length of time for which extrapolated activity data is used (in accordance with Ch 5.3.3.4 using trend extrapolation to resolve data gaps) Consistent time series with harvested private native forest and other parts of the national inventory including UNFCCC Harvested Native Forests, to more accurately reflect emissions trends across forest management reporting
WA lookup	-0.04	<ul style="list-style-type: none"> Cumulative correction Modelling of correct subset of raw harvest data for WA Using FMRL raw harvest data 	Criteria 2.e recalculation of historical harvest rates	<ul style="list-style-type: none"> Corrected error in activity data requiring recalculation of historical emissions trends (in accordance with <i>good practice</i>: Ch 5.2.1 Recalculations due to methodological changes and refinements)
NSW Allocation correction	2.00	<ul style="list-style-type: none"> Using additional data points to allocate harvest Using FMRL raw harvest data 	Criteria 2.e recalculation of historical harvest rates	<ul style="list-style-type: none"> Methodological refinement to utilise new activity data (in accordance with <i>good practice</i>: Ch 5.2.1 Recalculations due to methodological changes and refinements) Allocation better supported by including harvest information available after submission of FMRL
Prescribed Burning	0.03	<ul style="list-style-type: none"> Updated GWPs from IPCC AR4 Updated activity data to maintain methodological consistency with timeseries used for reporting 	Criteria 2.d recalculation of historical data on forest characteristics and related management	<ul style="list-style-type: none"> GWP for NO₂ and CH₄ updated in accordance with IPCC (2007) Recalculation of historical activity data (prescribed burning area) to enable reporting of time series and trends in accordance with <i>good practice</i> (IPCC 2006: Ch 5.2.3) Correction to maintain methodological consistency between reported timeseries and FMRL (IPCC 2014 Ch 2.7.5.2)

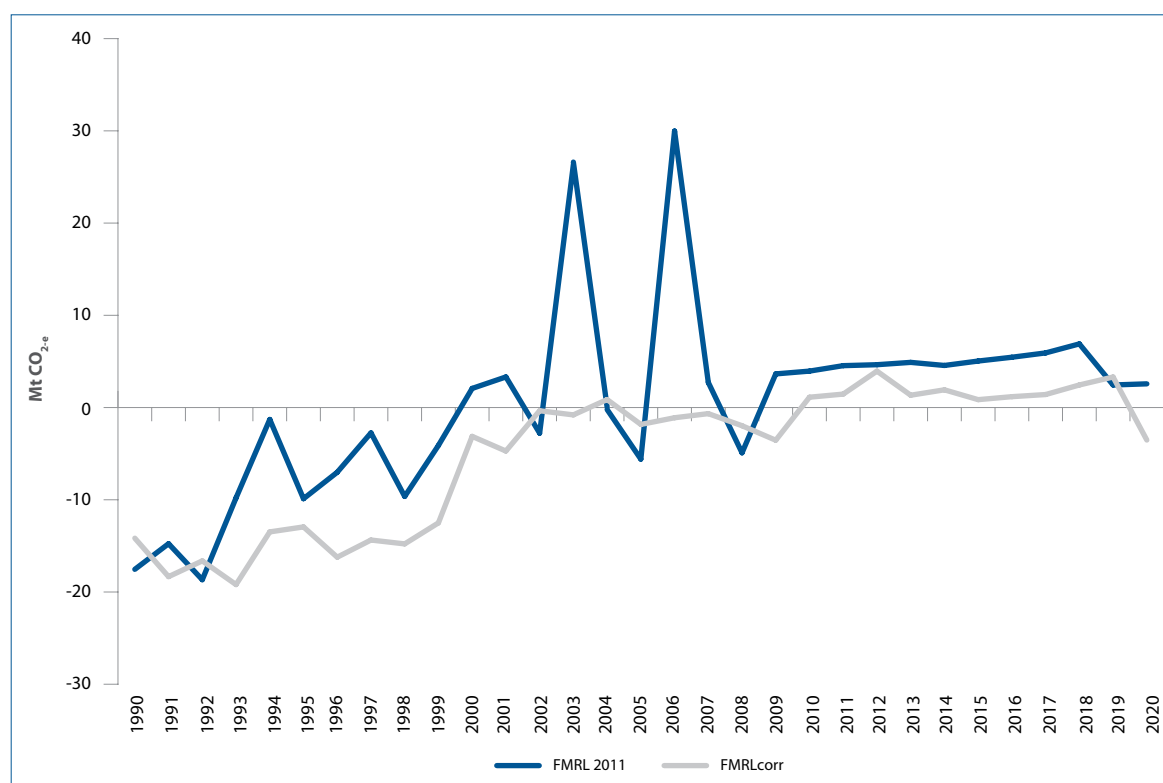
Component of forest management Correction	Technical Correction (Mt CO ₂ e)	Factors leading to correction	IPCC (2013) Guidance Criteria	Reason for methodological change or methodological refinement (References to 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol 1)
Fuelwood	0.31	<ul style="list-style-type: none"> New activity data based on NERS reporting and emissions factors from the Energy sector 	Criteria 2.e recalculation of historical harvest rates	<ul style="list-style-type: none"> Methodological refinement to utilise new activity data (in accordance with <i>good practice</i>: Ch 5.2.1 Recalculations due to methodological changes and refinements) New data ensures consistency of estimation method across the inventory (including energy)
Pre-1990 plantations	2.4	<ul style="list-style-type: none"> Implementation of tree yield formula to model biomass, permitting utilisation of climate data Estimation of soil carbon pool 	Criteria 2.d recalculation of historical data on forest characteristics and related management	<ul style="list-style-type: none"> Methodological refinement to utilise new model capability (in accordance with <i>good practice</i>: Ch 5.2.1 Recalculations due to methodological changes and refinements) New soil carbon and tree yield formula improves consistency with other reporting categories, including <i>afforestation/reforestation</i>.
Natural Disturbances	-6.1	<ul style="list-style-type: none"> Implementing IPCC (2014) methods and guidance, including calculation of background level and margin 	Criteria 2.h new data and methods for accounting for natural disturbances	<ul style="list-style-type: none"> Updated supplementary methods and good practice guidance finalised after submission of the FMRL (IPCC, 2014)
Harvested Wood Products	-3.7	<ul style="list-style-type: none"> Addressing Decision 2/CMP.7 and IPCC (2014), including by calculating emissions from the exports pool and excluding the imports pool 	Criteria 2.g New/recalculated data and methods and inclusions of provisions for Harvested Wood Products	<ul style="list-style-type: none"> Internationally agreed rules (Decision 2/CMP.7) on accounting for harvested wood products and Updated supplementary methods and good practice guidance (IPCC, 2014) finalised after submission of the FMRL

Table 11.21 reports the technical correction for 2013 (the accounting quantity is reported below at section 1.6.6.2), and Figure 11.13 shows a plot of the temporal dynamics of the estimates underlying the FMRL_{corr} and FMRL (refer to IPCC (2014) Ch 2.7.6.2).

Table 11.21: Summary table for reporting of technical correction

Summary table for technical correction (Table 2.7.2, IPCC, 2014)		
Forest Management Reference Level recalculated for the purpose of calculating the Technical Correction (FMRL _{corr})	1,117	Gg CO ₂ -e
Forest Management Reference Level (FMRL)	4,724	Gg CO ₂ -e
Difference in Percent	76	%
Technical Correction	-3,608	Gg CO ₂ -e

Figure 11.13: Comparison of recalculated reference level emissions (FMRL_{corr}) with previous estimates (FMRL)



* Note: the FMRL includes emissions from wildfires, consistent with the reference level inscribed in the Annex to Decision 2/CMP.7. The FMRL_{corr} time series applies the background level for natural disturbances emissions for all years.

11.6.4.1 Rationale for calculating FMRL_{corr}

Native forest harvesting from multiple use public forests and private native forest harvesting

The total technical correction for harvested private native forests is (3.05 Mt CO₂-e) and includes a change in methodology. In the 2011 FMRL submission (DCCEE, 2011) private native forests was estimated separately for Tasmania, using the FullCAM model, and the remaining States using an alternative model based on earlier inventory systems. The revised reference level estimates harvested private native forest on a nationally consistent basis using FullCAM.

The combined correction for multiple-use public forests is 2.17 Mt CO₂-e, and the result of number of smaller revisions to harvesting data, methods or assumptions. The details of the technical corrections are outlined in Table 11.20, and the rationale for the main changes reflected in the FMRL are outlined below.

In order to maintain consistency between the FMRL and the reporting of *forest management* for harvested private native forests (in accordance with paragraph 14 of Annex to decision 2/CMP.7) the same forest area applied in the FMRL has been used for *forest management* reporting. To achieve this, it was assumed that the reference level harvesting rate represents the total area of harvested private native forests that is available for harvest. Any reduction in harvesting compared to the reference level therefore represents forests within the private native forests estate not being harvested, rather than a reduction in the area of harvested private native forest (see section 1.6.2 for definition of lands included in *forest management*). Any increases in harvesting activity relative to the reference level projections will require a technical correction to the FMRL to ensure consistency in the area under *forest management* between the FMRL and reporting of *forest management*.

There has been a small technical correction to estimates of prescribed burning. This correction applies updated factors for the relative global warming potential (GWPs) of non-CO₂ emissions (IPCC, 2007). The correction also applies a methodology that can be replicated in the reporting period, utilising the State Government activity data on prescribed burning and allocating this to *forest management* and non-*forest management* land in each state. Consistent with the policies included in the 2011 FMRL submission, where there is a reported pre-2010 policy stating a prescribed burning target for state forest land, this target continues to be used. For States where no applicable policy on prescribed burning targets in multiple-use public forests was available, average prescribed burning areas between 2002 and 2009 have been used to project prescribed burning for the FMRL_{corr}. The total prescribed burning area for these States was adjusted for slash burning (emissions from slash burning are calculated in FullCAM) and allocated between multiple-use public forests and other forest lands based on relative forest area.

New nationally consistent activity data has been implemented for harvesting in multiple-use public forests as described in section 1.6.3.2. This has not resulted in a change of methods, however in the 2011 FMRL submission, due to lack of activity data on native forest harvesting in Queensland, harvesting from this state was calculated based on harvesting of equivalent forest types in the neighbouring state of New South Wales. The new activity data now includes harvesting from Queensland, resulting in changes to the reference level harvest area for this state and contributing to the technical correction.

Adjustment have been made to the area under *forest management* and to harvesting activity data to account for the transfer of lands from *forest management* to *deforestation* where land-use-change is observed (Section 1.2.3.1). Historical average deforestation rates were used to project deforestation rates for the FMRL_{corr}. Future recalculations to deforestation will result in technical corrections to the FMRL and changes to the area under *forest management*.

Fuelwood estimates have been updated to improve consistency with methods and emissions factors used in the energy sector.

Pre 1990 plantations

For Pre-1990 plantations the refinements include the operation of FullCAM in Estate mode and the implementation of tree yield formula method of tree production.

Changes in soil carbon are also estimated with FullCAM using Roth-C soil carbon model, a recent soil carbon map (Appendix 6.E) as the base input and location specific climate and site data. As a result of this change, the total annual carbon change during 1990-2013 shows greater variation compared to variations in the previous submission, reflecting variability in climate data and site productivity over the years.

Natural disturbances provision

Australia's FMRL submission contained a number of estimates of potential reference emissions levels to address the accounting risks of natural disturbances. These calculations were undertaken prior to the finalisation of the precise details of the natural disturbance provision contained in Decision 2/CMP.7. Therefore, Australia's FMRL must be corrected to ensure there is no expectation of net debits or credits due to the application of the natural disturbance provision. This circumstance is recognised in IPCC 2014, page 2.95, as a reason to generate a technical correction.

An allowance of 8.7 Mt CO₂-e per annum from wildfires on *forest management* lands was made in the 2011 FMRL submission. The new background level for natural disturbances is 2.6 Mt CO₂-e per annum. As a result, the FMRL was reduced by the difference between 8.7 Mt CO₂-e and 2.6 Mt CO₂e, which is -6.1 Mt CO₂-e.

Correcting the background level and margin for expected changes in the area of land under forest management

Guidance is provided in IPCC (2014) page 2.50 that indicates that technical corrections need to be made when the area under *forest management* changes during the commitment period. An approach to correcting for these situations is provided in Box 2.3.8 on page 2.53.

Some lands will enter the *forest management* area as a result of new harvesting activities on privately managed forests.

The following approach has been used to avoid an expectation of net credits and net debits when the area of *forest management* increases during the commitment period:

1. Include all observed wildfire on the new *forest management* land in a recalculation of the background level and the background level plus margin
 - Without this step there is an expectation of net debits as the area which is monitored for wildfire during the commitment period is larger than that included in the background level plus margin.
2. Test that the recalculated background level plus margin meets the four IPCC quality criteria (see Section 1.6.4.3).
3. Apply the revised background level and background level plus margin to reporting for all years of the commitment period, making any necessary re-calculations of reported emissions.

Harvested Wood Products

The correction due to revisions in HWP activity data and methods was 1.01 Mt CO₂-e.

11.6.5 Reporting of forest management in 2013

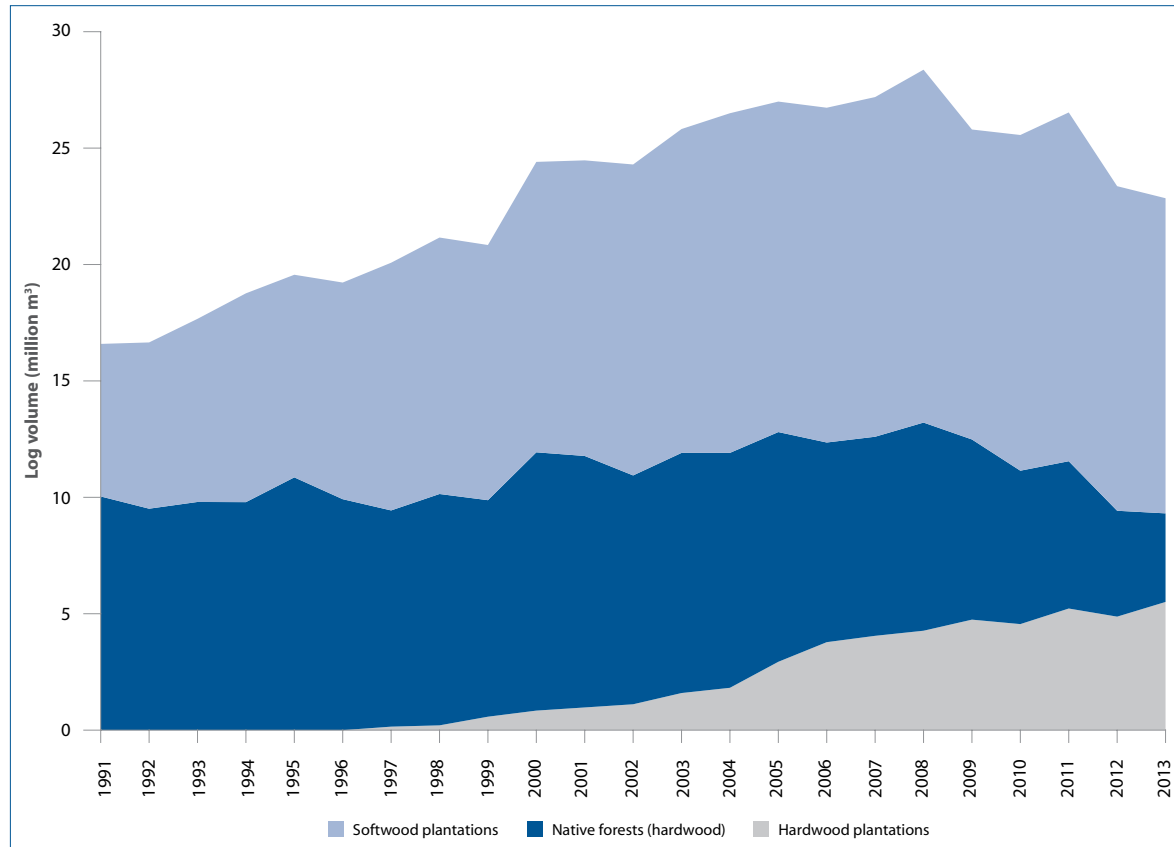
11.6.5.1 Reporting of forest management net emissions in 2013

In accordance with *good practice* the emissions and removals *forest management* are estimated using the same methodologies, models and activity data as were used in the calculation of FMRL_{corr}, described above in Section 1.6.3.

The main factor affecting the trends in *forest management* net emissions in 2013 is the decline in emission from native forest harvesting from multiple-use public forests and harvested private native forest. This corresponds to a change in activity levels that also impacts on the harvested wood products pool and related emissions. The importance of this trend in activity data to overall emissions from *forest management* is shown in the correlation in Figure 11.15 below.

Australian forest production statistics indicate a rapid decline in production from native forest harvesting (from multiple-use public forests and harvested private native forest) has occurred since 2008-2009 (ABARES, 2014a) (Figure 11.14). This has been part of a broader structural transition in the forest production industry in Australia.

Figure 11.14: Forest production in Australia (1991-2013)



Source: ABARES (2014a)

Constraints on timber supply from native forests and favourable policy and economic conditions for plantation establishment resulted in a peak in reported new plantation establishment for hardwood plantations in 1999-2000 (ABARES 2014b). Emissions and removals from these plantations are reported under *afforestation/reforestation*. Due to the standard rotation lengths for commonly used hardwood plantation species the new plantations established during these periods are beginning to be harvested, causing rapid increases in hardwood plantation production rates (Figure 11.14).

This increase the supply of plantation hardwood in Australia, in combination with broader economic factors affecting the forest industry, has lead to the observed decline in harvesting from native forests in particular through the substitution of log production from native forests with production from plantations.

Currently harvesting activity levels in multiple-use public forests and harvested private native forests are below reference levels. This decline in activity levels is reflected in reported emissions from *forest management* (Table 11.22).

Table 11.22: Estimated emissions from *forest management* (ktCO₂-e)

	Multiple-use public forest	Private harvested native forests	Pre-1990 plantations	Harvested wood products	Natural disturbances	Total
2000	-5,300.75	7,103.20	-1,893.05	-4,222.29	1,175.01	-3,137.88
2005	-9,288.41	5,017.45	2,202.47	-4,577.37	4,790.86	-1,854.99
2010	-14,767.40	1,212.44	5,543.99	-3,678.46	2,634.00	-9,055.43
2011	-17,281.46	-560.41	5,300.57	-3,756.51	1,256.87	-15,040.95
2012	-20,316.06	-2,741.46	7,267.84	-2,890.59	5,601.04	-13,079.24
2013	-21,651.37	-3,362.20	4,185.55	-2,060.15	2,634.00	-20,254.16

11.6.5.2 Reporting of *forest management* Accounting Quantity in 2013

Estimates of the accounting quantity for *forest management* – to be used to estimate the amount of RMU credits to be issued – are reported in Table 11.23. Estimates are derived by deducting the reported net emissions in 2013 from the FMRL after technical correction. Note that Australia has elected to account for Article 3.4 activities at the end of the commitment period.

Table 11.23: Estimated accounting quantity for Forest management (kt CO₂-e)

	FMRL corr	Forest management	Accounting Quantity (RMU credits)
2013	1,117	-20,254	21,371

11.6.5.3 Reporting of conversion of natural forests to planted forests (Annex to Decision 2/CMP.7, paragraph 5)

Available evidence indicates that conversion of multiple-use public forests to plantations no longer occurs in Australia as a result of state and territory regulations. Historically such conversions were a notable component of new plantation establishment in Tasmania, however the area of converted forests in this state is reported as nil for 2013. Reporting of emissions from the conversion of natural (native) forests to planted forests (plantations) is included in reported emissions under *forest management*.

11.6.6 Quality Assurance – Quality Control

11.6.6.1 Quality Control

In addition to the tests reported under section 1.6.4 (relating to the natural disturbances provision), four Quality Control tests are reported aimed at demonstrating methodological consistency and the avoidance of credits or debits between the FMRL and estimates of net emissions from *forest management* from methodological inconsistency.

- Comparison of the initial FMRL (DCCEE, 2011) and FMRL_{corr};
- Reproduction of the historical time series in the reporting of *forest management* and the forest management reference level (IPCC 2014, pages 2.100, 2.103);
- A quantitative comparison of trends in native forest wood production and emissions from *forest management* from 2002 to 2013 (IPCC 2014, p2.97); and
- Reconciliation of estimates used for the FMRL with estimates from *forest land remaining forest land*.

(i) Comparison of the initial FMRL (DCCEE, 2011) and FMRL_{corr}

Comparison of the FMRL (DCCEE, 2011) and FMRL_{corr} improves transparency by highlighting the main factors generating the technical correction. Such a comparison shows that the technical correction predominantly reflects changes in activity levels and the area under *forest management* relating to multiple-use public forests and harvested private native forests categories. For harvesting from multiple-use public forests the reference level harvesting rate was revised from approximately 88,500 ha yr⁻¹ in FMRL to approximately 91,800 ha yr⁻¹ in FMRL_{corr} and this is reflected in the overall positive technical correction to the FMRL (2.2 Mt CO₂-e, Table 11.24). For harvested private native forests the area under *forest management* has approximately doubled (from 390,000 ha to 910,000 ha) resulting in additional forests area acting as a carbon sink, and an overall negative technical correction (-3.1 Mt CO₂-e, Table 11.24).

Table 11.24: Native forest harvesting reference level and key activity data

Component of FMRL Technical Correction	Technical Correction by component	Original FMRL submission			Updated FMRL (FMRL _{corr})		
	(Mt CO ₂ -e)	RL (Mt CO ₂ -e)	Harvest Rate (Ha/yr)	Area under FM (M ha)	FMRL _{corr} (Mt CO ₂ -e)	Harvest Rate (Ha/yr)	Area under FM (M ha)
Private Native Harvest	-3.1	9.6	16,764	0.39	6.5	16,483	0.91
Multiple-use public forests	2.2	-9.1	88,537	9.40	-6.9	91,804	9.25

(ii) Reproduction of the time series used for the FMRL using methods used to estimate net emissions for forest management

It is *good practice* to provide information that there is no expectation of net credits or net debits linked to any methodological inconsistency between FMRL_{corr} and reporting for *forest management* (IPCC, 2014, pages 2.102-2.103).

Methodological consistency and the avoidance of credits or debits can be shown by reproducing the same historical time series in the reporting of *forest management* and the forest management reference level (IPCC 2014, pages 2.100, 2.103). This historical reproduction (Table 11.25) demonstrates that the difference in estimated emissions between the FMRL and the reporting of *forest management* is linked to variations in the activity data during the period since 2009. Remaining model variables have been addressed in the construction of FMRL_{corr}, as described in Section 1.6.3.

Table 11.25: Time series comparison of FMRL and reporting of forest management

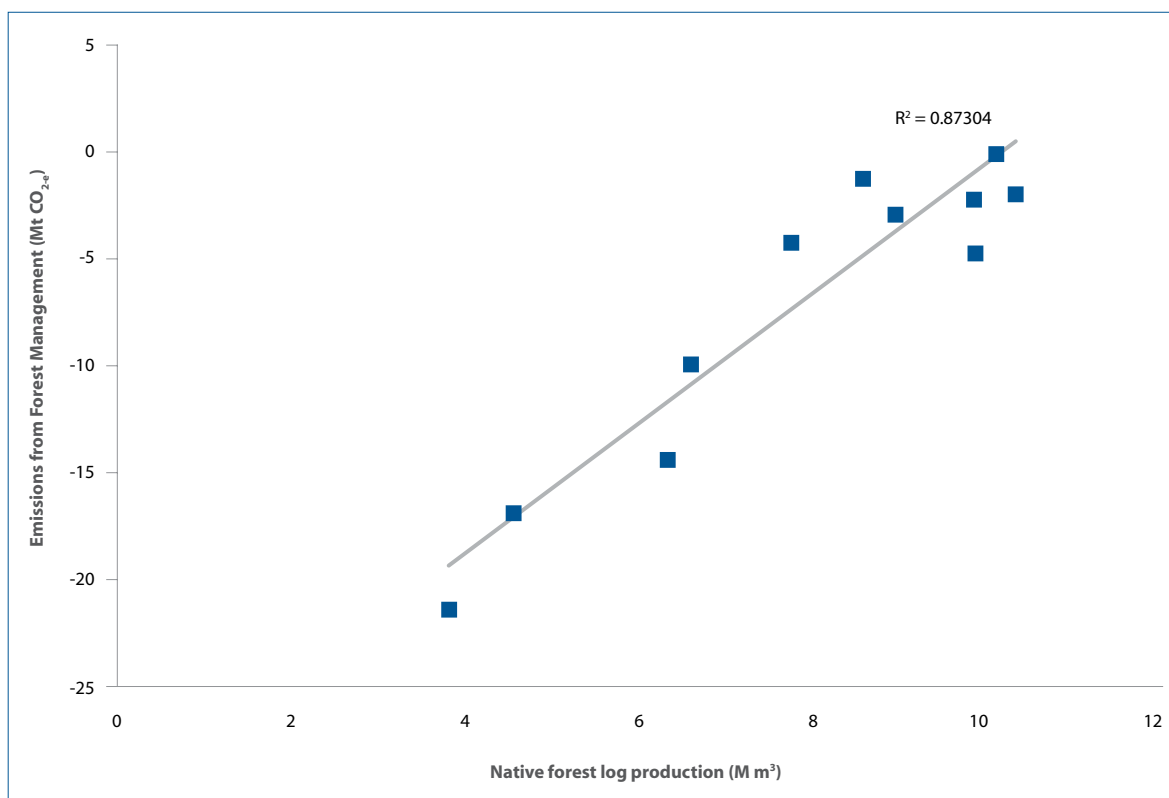
Historical time series used for constructing FMRL _{corr}		Reporting of FM
Emissions / Removals (Mt CO ₂ -e)		
1990	-14.2	-14.2
1995	-12.9	-12.9
2000	-3.1	-3.1
2002	-0.4	-0.4
2005	-1.8	-1.8
2006	-1.1	-1.1
2007	-0.7	-0.7

Historical time series used for constructing FMRL _{corr}		Reporting of FM
Emissions / Removals (Mt CO ₂ -e)		
2008	-2.0	-2.0
2009	-3.7	-3.7
2010	na	-9.1
2011	na	-15.0
2012	na	-13.1
FMRL _{corr}		2013 reported emissions
1.1		-20.3

(iii) Quantitative comparison of trends in native forest wood production and emissions from forest management

A quantitative comparison of trends in native forest wood production and emissions from *forest management* from 2002 to 2013 is shown in Figure 1.15 (IPCC 2014, p2.97). This provides evidence that the main factor generating the accounting quantity is the decline in harvesting activity from native forests, specifically multiple-use public forests and private native harvesting relative to the activity levels assumed in the FMRL.

Figure 11.15: Correlation of estimated emissions from forest management and native forest log production (2002-2013)



(iv) Reconciliation of *forest management* with *forest land remaining forest land* reporting

In accordance with *good practice*, the area of lands subject to *forest management* have been reconciled against the relevant categories within *forest land remaining forest land* in Table 11.26 below.

Table 11.26: Reconciliation of UNFCCC forest lands and *forest management* lands

Forest land remaining forest land category	forest management sub-classifications	Estimated area in 2013 (M ha)
Plantations	Pre-1990 plantations (commercial plantations not included under Article 3.3)	0.82
Harvested native forests	Multiple use forests	9.25
	Private native forests (where harvest has been observed and which have been included in <i>forest management</i>)	0.91
	Lands transferred to conservation reserves prior to 2009 (not included in <i>forest management</i>)	4.57
<i>subtotal</i>		14.72
Other native forests		84.38

Pre-1990 plantations included in *forest management* are equivalent to *plantations* reported under *forest land remaining forest land*.

The combined emissions from multiple-use public forests and private native harvesting forests are a subset of the *harvested native forest* category (Table 11.26). The difference in area is a result of lands, that were previously available for harvesting, transitioning to conservation reserves prior to December 2009 (Montreal Implementation Group 2008).

Wildfire, fuelwood and prescribed burning emissions for *forest management* lands are a subset of the emissions reported for *forest land remaining forest land*. Harvested wood products from *forest management* lands are not reported in the corresponding categories of *forest land remaining forest land* and instead are reported in aggregate under Chapter 4G – Harvested wood products.

Table 11.27 provides a reconciliation of emissions estimates between the reporting categories of *forest management* and *forest land remaining forest land*.

Table 11.27: Reconciliation of forest management with forest land remaining forest land emissions (Mt CO₂e)

Forest land remaining forest land	Plantations	Harvested Native Forests					lands transferred to conservation reserves	Harvested Native Forest Total	Other Native Forest total (Wildfires, controlled burning including savannah burning, fuelwood)	Forest land remaining forest land total
		Pre 1990 plantations	Multiple-use public forests	Private Native forest harvesting	Prescribed Burning ^a	Fuelwood ^a	harvested wood products ^b	Natural disturbances ^a		
Forest Management										
1990	-10.9	-9.6	-9.6	4.9	0.1	1.4	-1.5	1.4	-14.2	-28.9
1995	-11.4	-8.9	-8.9	5.3	0.1	1.6	-3.5	3.8	-12.9	-23.5
2000	-1.9	-7.1	-7.1	7.1	0.1	1.7	-4.2	1.2	-3.1	-2.5
2005	2.2	-11.0	-11.0	5.0	0.1	1.6	-4.6	4.8	-1.9	-5.8
2010	5.5	-16.4	-16.4	1.2	0.1	1.5	-3.7	2.6	-9.1	-8.2
2011	5.3	-18.8	-18.8	-0.6	0.1	1.4	-3.8	1.3	-15.0	-12.9
2012	7.3	-21.8	-21.8	-2.7	0.1	1.4	-2.9	5.6	-13.1	-25.4
2013	4.2	-23.2	-23.2	-3.4	0.1	1.4	-2.1	2.6	-20.3	-25.2

a Not reported separately under harvested native forests but are reported in total for forest land remaining forest land

b Harvested wood products are not reported separately under Forest land remaining forest land, but are included under 4G-Harvested Wood Products

11.6.6.2 Quality Assurance

The estimation of the implementation of the natural disturbance was reviewed in S. Fedrici (2015) prior to finalisation.

11.6.7 Recalculations

Nil.

11.7 Cropland management

Anthropogenic emissions and removals on croplands occur as a result of changes in management practices on cropping lands, from changes in crop type – particularly between herbaceous and woody crops – and from changes in land use. *Permanent* changes in management practices generate changes in the levels of soil carbon or woody biomass stocks over the longer term – and it is this process of change or transition to a higher or lower carbon stock level that generates net sequestration or net emissions of carbon dioxide that are reported in the inventory.

11.7.1 Identification of land subject to *cropland management*

Cropland management includes all land that is used for continuous cropping and those lands managed as crop-pasture (grassland) rotations as well as the land converted to cropland from grassland.

Forest land converted to cropland from 1990-2013 is identified based on attribution of the Landsat time series and is included under *deforestation*. Forest land converted to cropland prior to 1990 is identified based on attribution of the Landsat time series and is included under *cropland management*.

Land converted to forest land, or land that is identified as forest land from the Landsat series, is excluded from croplands.

Perennial crops including orchards and vineyards are included under the *cropland* classification in the UNFCCC inventory and hence are included under *cropland management*. Units of land where orchards were established on land clear of forest on 31 December 1989 are included in the *cropland management* and not the *afforestation/ reforestation* classification.

Land subject to *cropland management* is identified using a reporting method two land identification system (IPCC, 2014, Chapter 2.2.2). The area of *cropland management* includes all land classified as cropping land in the ABARES Land Use Map Version 5 subject to a number of amendments.

FullCAM simulates on a pixel by pixel (25m²) level and the carbon stock change on each pixel are tracked from the start of the simulation to the reporting year. The outputs of the simulations are stored in a datacube which can be queried using the Outputs Analysis System (OASys). OASys supports the reporting of the geographical location of the boundaries of the area that encompass land subject to *cropland management* annually, along with the total land areas subject to this activity.

11.7.2 Identification of management practices

According to the IPCC (2014), the aim of this reporting exercise is to identify and report trends and systematic changes in the carbon stocks resulting from changes in *cropland management* practices over time. The premise is that changes in soil carbon stocks result from changes in *cropland management* practices that influence the rates of

either additions to, or losses of, soil organic carbon.

Specified management practices affecting anthropogenic emissions and removals from *cropland management* include:

- total cropping area;
- crop type and rotation (including pasture leys);
- stubble management, including burning practices;
- tillage techniques;
- fertiliser application and irrigation;
- application of green manures (particularly legume crops);
- soil ameliorants (application of manure, compost or biochar) as well as from
- changes in land use from grassland.

Carbon dioxide emissions from the application of lime are reported under *agriculture*. Nitrous oxide emissions from the application of fertiliser are also reported under *agriculture*.

11.7.3 Methods for estimating carbon stock change and emissions due to management changes over time

Emissions and removals from *cropland management* activities are estimated using methods consistent with IPCC 2006 in conjunction with techniques described in IPCC 2014.

Carbon dioxide emissions and removals from the *cropland remaining cropland* soils component are estimated using the Tier 3 model FullCAM (Appendix 6.B).

The carbon dioxide emissions and removals associated with changes in the area of perennial woody crops are estimated using the Tier 2 approach outlined in section 6.8, Volume 2.

11.7.3.1 Data

Data sources for the estimation of *cropland management* are reported in Section 6.8, Volume 2. Soil carbon and clay content values are taken from the finely disaggregated soil maps (Viscarra-Rossel et al 2014, Viscarra-Rossel, 2014) – see Volume 2, Appendix 6.E – which permit organic soils to be distinguished from mineral soils. Organic soils occur only rarely in Australia.

Data on management practices are derived from ABS statistics. The climate, site and management datasets are those used in the forest land converted to cropland estimates as described in Volume 2, Appendix 6.B and 6.E.

11.7.3.2 Methods

The IPCC (2014) includes provision to reduce inter-annual variability and isolate the impacts of changes in human activities by calculating two time series of emissions and removals in which only the rate of human activities differ.

To implement this technique, FullCAM is simulated once with the time series of actual management practices and once with management practices held constant at 1990 levels. The difference between these two time series is an estimate of the impacts of changes in human activities over time since 1990. The impacts of inter-annual variability in climate and natural disturbances are the same in both scenarios and cancel each other out (IPCC 2014, 2.31).

In this way, estimates of net emissions mimic the outcomes of a tier1/2 approach in which the effects of management practice changes are isolated from all other impacts on soil carbon (IPCC 2014, p2.135) (for example, as is done for estimates of the emissions from liming in this report). Similarly, under *Agriculture*, in this report, nitrous oxide emissions from the effects of management practice changes are isolated in tier 1 or tier 2 methods (for example, from the effects of the current year's application of fertiliser).

It is good practice to document whether the methods selected for the estimation of emissions and removals are sensitive to inter-annual variability of environmental conditions during the CP, and to report how inter-annual variation was addressed in the inventory calculations (IPCC 2014, page 2.33). The effects of inter-annual variability, and how they have been addressed, have been reported in Volume 2, Section 6.8.1.

Perennial woody crops are estimated using tier 2 methods described in Volume 2.

11.7.3.3 Start year

Estimation of net emissions is undertaken from 1970 consistent with IPCC good practice (IPCC 2014, p 2.137).

11.7.3.4 Carbon pools

FullCAM estimates emissions from soil as a result of an estimation process involving all on-site carbon pools (living biomass, dead organic matter and soil).

For non-woody crops, only the changes in the soil carbon pool are reported. Decision 2/CMP.7 specifies that a Party may choose not to account for a given pool, except for HWP, in a CP, if transparent and verifiable information is provided that the pool is not a source using reasoning based on sound knowledge of likely system responses (IPCC 2014, page 2.26). Carbon stock changes from living biomass and DOM of non-woody annual crops have been excluded as they do not constitute a source based on reasoning provided by the guidance in IPCC 2006. In particular, for annual crops, increases in biomass stocks in a single year may be assumed equal to biomass losses from harvest and mortality in that same year (IPCC 2006, p5.7) and, in general, croplands will have little or no dead wood, crop residues or litter (IPCC 2006, p5.12).

The purpose of excluding these pools is aimed at ensuring that reported inventory estimates reflect trends and systematic changes in the carbon stocks resulting from changes in *cropland management* practices over time (IPCC 2014, page 2.135) and do not reflect inter-annual variability driven by climate fluctuations or natural disturbances (IPCC 2014, page 2.135).

For perennial woody crops, estimates are reported for changes in carbon stocks or net emissions from above and below ground biomass. Net emissions from DOM or soil carbon have not been estimated.

11.7.4 Reporting of *cropland management* in 2013

11.7.4.1 Reporting of *cropland management* net emissions in 2013

Estimates of net emissions from *cropland management* are reported in Table 11.28.

Table 11.28: Estimated emissions from *cropland management* (ktCO₂-e)

	Annual crops	Woody crops	Forest converted to cropland prior to 1990	Nitrogen mineralisation	Total
1990	0	-69	4,428	13	4,373
2000	-8,413	-50	875	5	-7,583
2005	777	-162	343	8	967
2006	152	-175	1,008	5	990
2007	-5,575	36	396	7	-5,136
2008	2,663	-122	137	6	2,683
2009	863	-152	480	7	1,197
2010	-4,745	-282	83	14	-4,930
2011	2,160	-363	11	6	1,814
2012	-3,170	-109	485	6	-2,788
2013	-2,310	94	454	8	-1,755

11.7.4.2 Estimation of *cropland management* Accounting Quantity in 2013

For the Article 3.4 land activity categories credits (called RMU credits) are to be issued against the reduction in net emissions relative to a specified benchmark base year or reference level. If net emissions are higher in the reporting year than in the 1990, AAUs or RMUs are to be cancelled.

For *cropland management* estimates of the accounting quantity – to be used to estimate the amount of RMU credits to be issued – are reported in Table 11.29. Estimates are derived by deducting the reported net emissions in 2013 from the reported net emissions in 1990. Note that Australia has elected to account for Article 3.4 activities at the end of the commitment period.

Table 11.29: Estimated accounting quantity for *cropland management* (kt CO₂-e)

	CM 1990 ^a	CM 2013	Accounting Quantity (RMU credits)
2013	-68.73	-1,755	1,685.92

a In this report, crop land management estimates for 1990 were adjusted for the emissions reported under Forest Conversion in the UNFCCC inventory in 1990 and recorded in the report used to calculate the assigned amount, in order to avoid double counting.

11.7.5 Quality Assurance – Quality Control

Refer to chapter 6.8.

11.7.6 Recalculations

Nil.

11.8 Grazing land management

Grazing Land Management is the system of practices on land used for livestock production aimed at manipulating the amount and type of vegetation and livestock produced.

11.8.1 Identification of land subject to grazing land management

Grazing land management lands includes grasslands, grasslands with sparse woody cover, and certain specified lands with forest cover – limited to situations in which the presence of grassland has been observed from the Landsat time series and where there has been no change in land use since 1990; or where savanna burning takes place.

Grasslands are identified using a reporting method two land identification system (IPCC, 2014, Chapter 2.2.2). The lands included in the *grassland* category are defined in Section 6.3.1, Volume 2.

Grassland excludes all land that is used for continuous cropping, lands managed as crop-pasture rotations and land converted to cropland from grassland at any time.

The *Grassland remaining grassland* classification includes shrub land vegetation. Emissions and removals due to shrubland transitions are established by the methods described in Section 6.8, Volume 2 and Section 6.2, Volume 2. Activity data for shrubland transitions are based on the national mapping programme to assess both the extent, and changes in extent, of sub-forest forms of woody biomass using the Landsat TM, ETM+ and OLI data for the years from 1988 to 2014.

Forest land converted to grassland after 1 January 1990 is identified based on attribution of the Landsat time series and is included under *deforestation*. If the conversion occurred prior to 1990, this land is included under *grazing land management*.

Land that has been observed to be converted to *forest land* in the Landsat time series after 1 January 1990 is included under *afforestation/reforestation*.

Land that is identified as *forest land* from the Landsat series is also excluded from *grasslands* but may in certain circumstances be reported under *grazing land management*. Lands which were *grassland* in 1990, and therefore included in *grazing land management*, remain in *grazing land management* even where increases in woody cover result in the land meeting the threshold parameters for *forest* provided there is no subsequent change in land use. A change in land use occurs if the increase in woody cover occurs on lands protected as forest by national, State or Territory regulations, in which case the land would be transferred to *afforestation/reforestation*. Alternatively, however, if the growth occurs outside a protected forest area, no change in land use occurs and the land remains in *grazing land management*.

Land that is identified as *forest land* from the Landsat series may also be incorporated under *grazing land management* where savanna burning takes place. Non carbon dioxide emissions from these fires are reported under the *Agriculture* sector, see Volume 1, chapter 5. The identification of fire areas in Australia's savanna lands is described in Volume 1, chapter 5.

Forest lands are not double counted in Australia's land classification systems for KP as a 'narrow' approach to *forest management* has been applied allowing specified forests not identified as being managed for timber to be included under *grazing land management*.

FullCAM simulates on a pixel by pixel (25m²) level. The outputs of the simulations are stored in a datacube which can be queried using the Outputs Analysis System (OASys). OASys supports the reporting of the geographical location of the boundaries of the area that encompass land subject to *grazing land management* annually, along with the total land areas subject to this activity.

11.8.2 Identification of management practices

The concepts underlying carbon stock changes in biomass of grassland remaining grassland are tied to management practices (IPCC 2006, p6.6).

Specified management practices affecting anthropogenic emissions and removals from *grazing land management* include:

- the area under grasslands;
- pasture management from fertilisers, irrigation and other inputs and seed selection;
- grazing management practices;
- woody biomass management; and
- fire management.

11.8.3 Methods to estimate changes in carbon stocks and emissions due to management changes over time

11.8.3.1 Data

Data sources for the estimation of changes in carbon stocks from changes in pasture management are reported in Section 6.8, Volume 2. Soil carbon and clay content values are taken from the finely disaggregated soil maps (Viscarra-Rossel et al 2014, Viscarra-Rossel, 2014) – see Volume 2, Appendix 6.E which permit organic soils to be distinguished from mineral soils. Organic soils occur only rarely in Australia.

Data on management practices are derived from ABS statistics. The climate, site and management datasets are those used in the forest land converted to cropland estimates as described in Volume 2, Appendix 6.B and 6.E.

11.8.3.2 Methods

Pasture Management

Areas of grassland are stratified, consistent with IPCC 2014, 2.135, step 5, by climate and pasture type to distinguish between productive pastures and rangelands.

The IPCC encourages countries to use higher tier methods to develop emissions coefficients or models to represent the effects of management practices rather than those of inter-annual variability and short term temporal dynamics (IPCC 2014, p2.149).

Changes in soil carbon stocks are estimated for productive pasture regions using FullCAM in accordance with techniques described in IPCC (2014).

For productive pastures, FullCAM is simulated once with management practices changing over time and once with management practices held constant at 1990 levels. The difference between these two time series estimates the impacts of changes in human activities. The impacts of inter-annual variability in climate and natural disturbances are the same in both scenarios and cancel each other out (IPCC 2014, 2.31).

It is good practice to document whether the methods selected for the estimation of GHG emissions and removals are sensitive to inter-annual variability of environmental conditions during the CP, and to report how inter-annual variation was addressed in the inventory calculations (IPCC 2014, page 2.33). The effects of inter-annual variability, and how they have been addressed, have been reported in Section 6.9, Volume 2.

Changes in carbon stocks for rangeland areas are assumed to be unchanged given limited pasture management activity, arid climate and low carbon soils.

Grazing management practices

For grazing management practices, the international literature which underpins IPCC (2014) and IPCC (2006) suggests that the impact of grazing on emissions and removals from grazing land activities can have important impacts on carbon stocks. In this report, however, the net effects of changes in grazing pressures on carbon stocks have not been estimated.

Woody biomass

The methods and data used for the estimation of net emissions from woody biomass management are described in Volume 2.

Fire management

The methods and data for estimating emissions from prescribed burning and wildfires on savanna lands is described in Volume 1, *Prescribed Burning of Savannas (3E)* and *Biomass Burning (4V)*. Net emissions on savanna grazing lands include the effects of fire management practices and wildfires caused by both human intervention and by lightning strikes. The extent of wildfire is driven by climatic events beyond the control of the party.

While Australia has not applied the natural disturbance provision to the net emissions from these savanna forest fires, it is good practice to document whether the methods selected for the estimation of greenhouse gas emissions and removals are sensitive to interannual variability of environmental conditions during the CP, and to report how interannual variation was addressed in the inventory calculations (IPCC 2014, page 2.33).

Consistent with previous practice, estimates of net emissions from savanna fires have been reported as five year averages of annual emission estimates. This approach has been adopted as a transparent, time-series consistent approach to the identification of trends and systematic changes in the carbon stocks resulting from changes in *grazing land management* practices over time. The main advantage of this approach is that it avoids the presentation of annual estimates driven by climate variability or natural disturbances (IPCC 2014, 2.149) while preserving the effects of non-linear relationships between net emissions and management practices and, therefore, is more accurate than approaches that average environmental data (IPCC 2014, page 2.32). With respect to comparability, the outcomes are not inconsistent with approaches that rely on measurements of carbon stock changes with intervals between measurements identified as being typical by the IPCC (ie typically, there is around five years between measurements of carbon stock changes) (IPCC 2014, page 2.32).

11.8.3.3 Start year

As for the *cropland management* category, FullCAM simulations commence in 1970.

11.8.3.4 Carbon pools

FullCAM estimates emissions from soil as a result of an estimation process involving all on-site carbon pools (living biomass, dead organic matter and soil).

For non-woody grasses, only the changes in the soil carbon pool are reported. Decision 2/CMP.7 specifies that a Party may choose not to account for a given pool, except for HWP, in a CP, if transparent and verifiable information is provided that the pool is not a source using reasoning based on sound knowledge of likely system responses (IPCC 2014, page 2.26). Carbon stock changes from living biomass and DOM of non-woody annual grasses have been excluded as they do not constitute a source based on reasoning provided by the guidance in

IPCC 2014. Herbaceous grassland vegetation is assumed to cycle annually such that biomass gains equal biomass losses in a single year (IPCC 2014, p2.153).

Excluding these pools ensures that reported estimates reflect trends and systematic changes in the carbon stocks resulting from changes in *grazing land management* practices over time (IPCC 2014, page 2.149) and do not reflect inter-annual variability driven by climate fluctuations or natural disturbances (IPCC 2014, page 2.149).

For woody vegetation or savannas, changes in soil carbon stocks have not been estimated.

11.8.4 Reporting of *grazing land management* in 2013

11.8.4.1 Reporting of *grazing land management* net emissions in 2013

Estimates of net emissions for *Grazing land management* are reported in Table 11.30.

Table 11.30: Estimated emissions from *Grazing land management* (ktCO₂-e)

	Grasslands	Savanna burning	Woody transitions	Forest converted to grassland prior to 1990	Total
1990	2,084	-1,190	-1,150	57,708	57,452
2000	-3,979	9,963	-842	10,330	15,472
2005	-6,829	11,223	-702	4,904	8,596
2006	-5,856	11,611	-638	6,888	12,004
2007	-7,626	10,618	-683	3,272	5,581
2008	-6,332	9,637	-527	2,257	5,034
2009	-5,515	7,497	-289	5,651	7,344
2010	-5,769	7,296	-183	9,266	10,610
2011	-6,893	5,543	-193	-1,520	-3,062
2012	-6,967	3,320	-248	4,353	459
2013	-6,583	8,051	-385	3,803	4,886

11.8.4.2 Estimation of *grazing land management* Accounting Quantity in 2013

For land activity categories other than *deforestation*, credits (called RMU credits) are to be issued against the reduction in net emissions relative to a specified benchmark base year or reference level. If net emissions are higher in the reporting year than in the 1990, AAUs are to be cancelled.

For *grazing land management* estimates of the accounting quantity – to be used to estimate the amount of RMU credits to be issued – are reported in Table 11.31. Estimates are derived by deducting the reported net emissions in 2013 from the reported net emissions in 1990. Note that Australia has elected to account for Article 3.4 activities at the end of the commitment period.

Table 11.31: Estimated accounting quantity for *grazing land management* (ktCO₂-e)

	GM 1990 ^a	GM 2013	Accounting Quantity (RMU credits)
2013	-257 ^a	4,886	-5,143

^a In this report, *grazing land management* estimates in 1990 were adjusted for the emissions reported under *Forest Conversion* in the UNFCCC inventory in 1990 and recorded in the report used to calculate the assigned amount, in order to avoid double counting.

11.8.5 Quality Assurance – Quality Control

Refer to chapter 6.8.

11.8.6 Recalculations

Nil.

11.9 Revegetation

Revegetation will potentially include net emissions from areas of vegetation that do not constitute a forest and which occur on non-grazing or cropping lands.

No estimates have been made of these activities for this report.

11.10 Other Information

11.10.1 Key category analysis

The key category analysis for Article 3.3 and relevant Article 3.4 activities are reported in Annex 1 and in Table 11.32.

Table 11.32: Summary overview for key categories for land use, land use change and forestry activities under the Kyoto Protocol.

Key Categories of Emissions and Removals	Criteria used for Key Category Identification				Comments
	Gas	Associated category in UNFCCC inventory is key	Category contribution is greater than the smallest category considered key in the UNFCCC inventory (including LULUCF)	Other	
Afforestation/ Reforestation	CO ₂	Land converted to forest	YES	NA	UNFCCC category is key, category is greater than smallest UNFCCC key category
Deforestation	CO ₂	Land converted to cropland Land converted grassland	YES	NA	UNFCCC category is key, category is greater than smallest UNFCCC key category
Deforestation	CH ₄	Land converted to cropland	NO	NA	UNFCCC category is key

12. Information on Accounting of Kyoto Units

12.1 Summary of information reported in the Standard Electronic Format Tables

Annex I Parties are required to report from its national registry holdings and transactions of Kyoto units in the previous calendar year. In accordance with decision 15/CMP.1 annex I.E paragraph 11 and as set out in draft decision FCCC/SBSTA/2014/L.29⁹. This information has been submitted in the standard electronic format (SEF) tables (tables 12.1 to 12.28).

⁹ <http://unfccc.int/resource/docs/2014/sbsta/eng/l29.pdf>

12.1.1 SEF reporting for commitment period 1 (CP1)

Table 12.1: SEF Table 1, Total quantities of Kyoto Protocol units by account type at beginning of reported year (CP1)

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Party holding accounts	2,851,869,652	NO	23,834,852	NO	NO	NO
Entity holding accounts	NO	NO	NO	45,102	NO	NO
Article 3.3/3.4 net source cancellation accounts	103,408,630	NO	46,294,933	NO		
Non-compliance cancellation account	NO	NO	NO	NO		
Other cancellation accounts	2,300,861	150,000	NO	128,826	NO	NO
Retirement account	NO	NO	NO	NO	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
ICER replacement account for expiry	NO	NO	NO	NO		
ICER replacement account for reversal of storage	NO	NO	NO	NO		NO
ICER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	2,957,579,143	150,000	70,129,785	173,928	NO	NO

Table 12.2: SEF Table 2(a), Annual internal transactions (CP1)

Transaction type	Additions						Subtractions			
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs
Art6 issuance and conversion										
Party verified projects		NO					NO		NO	
Independently verified projects		NO					NO		NO	
Art3.3 and 3.4 issuance or cancellation										
3.3 Afforestation reforestation			25,907,257				NO	NO	NO	NO
3.3 Deforestation			NO				NO	NO	38,543,673	NO
3.4 Forest management			NO				NO	NO	NO	NO
3.4 Cropland management			NO				NO	NO	NO	NO

Transaction type	Additions					Subtractions						
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
3.4 Grazing land management			NO				NO	NO	NO	NO		
3.4 Revegetation			NO				NO	NO	NO	NO		
Art 12 afforestation and reforestation												
Replacement of expired tCERs							NO	NO	NO	NO	NO	
Replacement of expired ICERs							NO	NO	NO	NO		
Replacement for reversal of storage							NO	NO	NO	NO		NO
Replacement for non-submission of certification report							NO	NO	NO	NO		NO
Other cancellation							NO	100,000	NO	167,436	NO	NO
Subtotal		NO	25,907,257				NO	100,000	38,543,673	167,436	NO	NO

Transaction type	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Retirement	NO	NO	NO	NO	NO	NO

Table 12.3: SEF Table 2(b), Annual external transactions (CP1)

Transfers and acquisitions	Additions					Subtractions						
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
CH	NO	NO	NO	16,675	NO	NO	NO	NO	NO	NO	NO	NO
EU	NO	NO	NO	252,331	NO	NO	NO	NO	NO	24,267	NO	NO
GB	NO	NO	NO	10,000	NO	NO	NO	NO	NO	100	NO	NO
NL	NO	NO	NO	80,745	NO	NO	NO	NO	NO	NO	NO	NO
NZ	NO	100,000	NO	354,203	NO	NO	NO	NO	NO	30,000	NO	NO
SE	NO	NO	NO	NO	NO	NO	NO	NO	NO	308,295	NO	NO
Subtotal	NO	100,000	NO	713,954	NO	NO	NO	NO	NO	362,662	NO	NO

Additional Information											
Independently verified ERU											
AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
NO											

Table 12.4: SEF Table 2(c), Total annual transactions (CP1)

AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Total (Sum of table 2(a) and 2(b))	NO	100,000	25,907,257	713,954	NO	NO	NO	38,543,673	530,098	NO	NO

Table 12.5: SEF Table 3, Expiry, cancellation and replacement (CP1)

Transaction or event type	Expiry, cancellation and requirement to replace			Replacement				
	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Temporary CERs (tCERs)								
Expired in retirement and replacement accounts	NO							
Replacement of expired tCERs			NO	NO	NO	NO	NO	
Expired in holding accounts	NO							
Cancellation of tCERs expired in holding accounts	NO							
Long-term CERs (ICERs)								
Expired in retirement and replacement accounts		NO						
Replacement of expired ICERs			NO	NO	NO	NO		
Expired in holding accounts		NO						
Cancellation of ICERs expired in holding accounts		NO						
Subject to replacement for reversal of storage		NO						
Replacement for reversal of storage			NO	NO	NO	NO		NO
Subject to replacement for non-submission of certification report		NO						
Replacement for non-submission of certification report			NO	NO	NO	NO		NO
Total	NO	NO	NO	NO	NO	NO	NO	NO

Table 12.6: SEF Table 4, Total quantities of Kyoto Protocol units by account type at end of reported year (CP1)

Account type	Unit type				
	AAUs	ERUs	RMUs	CERs	tCERs
Party holding accounts	2,851,869,652	NO	11,198,436	NO	NO
Entity holding accounts	NO	NO	NO	228,958	NO
Article 3.3/3.4 net source cancellation accounts	103,408,630	NO	84,838,606	NO	
Non-compliance cancellation account	NO	NO	NO	NO	
Other cancellation accounts	2,300,861	250,000	NO	296,262	NO
Retirement account	NO	NO	NO	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO
ICER replacement account for expiry	NO	NO	NO	NO	
ICER replacement account for reversal of storage	NO	NO	NO	NO	NO
ICER replacement account for non-submission of certification report	NO	NO	NO	NO	NO
Total	2,957,579,143	250,000	96,037,042	525,220	NO

Table 12.7: SEF Table 5(a), Summary information on additions and subtractions (CP1)

Starting Values												
Issuance pursuant to Article 3.7 and 3.8	Additions					Subtractions						
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
	2,957,579,143											
Annual Transactions												
Year 0 (2007)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 1 (2008)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 2 (2009)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 3 (2010)	NO	NO	NO	1	NO	NO	NO	NO	NO	1	NO	NO
Year 4 (2011)	NO	NO	23,032,901	126,851	NO	NO	49,650,531	NO	NO	75,851	NO	NO
Year 5 (2012)	NO	NO	23,262,032	102,714	NO	NO	44,164,557	NO	NO	123,712	NO	NO
Year 6 (2013)	NO	150,000	23,834,852	530,972	NO	NO	11,894,403	150,000	46,294,933	515,872	NO	NO
Year 7 (2014)	NO	100,000	25,907,257	713,954	NO	NO	NO	100,000	38,543,673	530,098	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Subtotal	NO	250,000	96,037,042	1,474,492	NO	NO	105,709,491	250,000	84,838,606	1,245,534	NO	NO
Total	2,957,579,143	250,000	96,037,042	1,474,492	NO	NO	105,709,491	250,000	84,838,606	1,245,534	NO	NO

Table 12.8: SEF Table 5(b), Summary information on replacement (CP1)

	Expiry, cancellation and requirement to replace		Replacement					
	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Previous CPs			NO	NO	NO	NO	NO	NO
Year 1 (2008)		NO	NO	NO	NO	NO	NO	NO
Year 2 (2009)		NO	NO	NO	NO	NO	NO	NO
Year 3 (2010)		NO	NO	NO	NO	NO	NO	NO
Year 4 (2011)		NO	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO	NO	NO
Total	NO	NO	NO	NO	NO	NO	NO	NO

Table 12.9: SEF Table 5(c), Summary information on retirement (CP1)

Year	Retirement					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Year 1 (2008)	NO	NO	NO	NO	NO	NO
Year 2 (2009)	NO	NO	NO	NO	NO	NO
Year 3 (2010)	NO	NO	NO	NO	NO	NO
Year 4 (2011)	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO
Total	NO	NO	NO	NO	NO	NO

Table 12.10: SEF Table 6(a), Memo item: Corrective transactions relating to additions and subtractions (CP1)

Additions						Subtractions					
Unit type						Unit type					
AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs

Table 12.11: SEF Table 6 (b), Memo item: corrective transactions relating to replacement (CP1)

Expiry, cancellation and requirement to replace			Replacement					
tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	

Table 12.12: SEF Table 6(c), Memo item: Corrective transactions relating to retirement (CP1)

Retirement					
AAUs	ERUs	RMUs	CERs	tCERs	ICERs

12.1.2 SEF reporting for commitment period 2 (CP2)

Table 12.13: SEF Table 1, Total quantities of Kyoto Protocol units by account type at beginning of reported year (CP2)

Account type	Unit type				
	AAUs	ERUs	RMUs	CERs	tCERs
Party holding accounts	NO	NO	NO	NO	NO
Entity holding accounts	NO	NO	NO	NO	NO
Retirement account	NO	NO	NO	NO	NO
Previous period surplus reserve account	NO				
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO	
Non-compliance cancellation account	NO	NO	NO	NO	
Voluntary cancellation account	NO	NO	NO	NO	NO
Cancellation account for remaining units after carry-over	NO	NO	NO	NO	NO
Article 3.1 ter and quarter ambition increase cancellation account	NO				
Article 3.7 ter cancellation account	NO				
tCER cancellation account for expiry					NO
ICER cancellation account for expiry					NO
ICER cancellation account for reversal of storage					NO
ICER cancellation account for non-submission of certification report					NO
tCER replacement account for expiry	NO	NO	NO	NO	NO
ICER replacement account for expiry	NO	NO	NO	NO	
ICER replacement account for reversal of storage	NO	NO	NO	NO	NO
ICER replacement account for non-submission of certification report	NO	NO	NO	NO	NO
Total	NO	NO	NO	NO	NO

Table 12.14: SEF Table 2(a), Annual internal transactions (CP2)

Transaction type	Additions					Subtractions						
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Art6 issuance and conversion												
Party verified projects		NO					NO		NO			
Independently verified projects		NO					NO		NO			
Art3.3 and 3.4 issuance or cancellation												
3.3 Afforestation reforestation			NO				NO	NO	NO	NO		
3.3 Deforestation			NO				NO	NO	NO	NO		
3.4 Forest management			NO				NO	NO	NO	NO		
3.4 Cropland management			NO				NO	NO	NO	NO		
3.4 Grazing land management			NO				NO	NO	NO	NO		
3.4 Revegetation			NO				NO	NO	NO	NO		
3.4 Wetland drainage and rewetting			NO				NO	NO	NO	NO		
Art 12 afforestation and reforestation												
Replacement of expired tCERs							NO	NO	NO	NO	NO	
Replacement of expired ICERs							NO	NO	NO	NO		
Replacement for reversal of storage							NO	NO	NO	NO		NO
Cancellation for reversal of storage												NO
Replacement for non-submission of certification report							NO	NO	NO	NO		NO
Cancellation for non submission of certification report												NO
Other cancellation												
Voluntary cancellation							NO	NO	NO	NO	NO	NO
Article 3.1 ter and quater ambition increase cancellation							NO					
Subtotal		NO	NO				NO	NO	NO	NO	NO	NO

Transaction type	Retirement					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Retirement	NO	NO	NO	NO	NO	NO
Retirement from PPSR	NO					
Total	NO	NO	NO	NO	NO	NO

Table 12.15: SEF Table 2(b), Annual external transactions (CP2)

Total transfers and acquisitions	Additions						Subtractions					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
CH	NO	NO	NO	10,000	NO	NO	NO	NO	NO	NO	NO	NO
EU	NO	NO	NO	NO	NO	NO	NO	NO	NO	120,870	NO	NO
NL	NO	NO	NO	120,870	NO	NO	NO	NO	NO	NO	NO	NO
SE	NO	NO	NO	NO	NO	NO	NO	NO	NO	10,000	NO	NO
Subtotal	NO	NO	NO	130,870	NO	NO	NO	NO	NO	130,870	NO	NO

Table 12.16: SEF Table 2(c), Annual transactions between PPSR accounts (CP2)

Subtotal	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 12.17: SEF Table 2 (d) Share of proceeds transactions under decision 1/CMP.8, paragraph 21 – Adaptation Fund (CP2)

	NO						NO					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
First international transfers of AAUs	NO											
Issuance of ERU from Party-verified projects		NO						NO				
Issuance of independently verified ERUs		NO						NO				

Table 12.18: SEF Table 2(e), Total annual transactions (CP2)

	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Total (Sum of sub-totals in table 2a and table 2b)	NO	NO	NO	130,870	NO	NO	NO	NO	NO	130,870	NO	NO

Table 12.19: SEF Table 3, Expiry, cancellation and replacement (CP2)

Transaction or event type	Requirement to replace or cancel			Replacement						Cancellation					
	tCERs	ICERs	CERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Temporary CERs															
Expired in retirement and replacement accounts	NO			NO	NO	NO	NO	NO							
Expired in holding accounts	NO													NO	
Long-term CERs															
Expired in retirement and replacement accounts		NO		NO	NO	NO	NO	NO							
Expired in holding accounts		NO													NO
Subject to reversal of Storage		NO		NO	NO	NO	NO	NO	NO						NO
Subject to non submission of certification Report		NO		NO	NO	NO	NO	NO	NO						NO
Carbon Capture and Storage CERs															
Subject to net reversal of storage			NO							NO	NO	NO	NO		
Subject to non submission of certification report			NO							NO	NO	NO	NO		
Total	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 12.20: SEF Table 4, Total quantities of Kyoto Protocol units by account type at end of reported year (CP2)

Account type	Unit type				
	AAUs	ERUs	RMUs	CERs	tCERs
Party holding accounts	NO	NO	NO	NO	NO
Entity holding accounts	NO	NO	NO	NO	NO
Retirement account	NO	NO	NO	NO	NO
Previous period surplus reserve account	NO				
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO	
Non-compliance cancellation account	NO	NO	NO	NO	
Voluntary cancellation account	NO	NO	NO	NO	NO
Cancellation account for remaining units after carry-over	NO	NO	NO	NO	NO
Article 3.1 ter and quater ambition increase cancellation account	NO				
Article 3.7 ter cancellation account	NO				
tCER cancellation account for expiry					NO
ICER cancellation account for expiry					NO
ICER cancellation account for reversal of storage					NO
ICER cancellation account for non-submission of certification report					NO
tCER replacement account for expiry	NO	NO	NO	NO	NO
ICER replacement account for expiry	NO	NO	NO	NO	
ICER replacement account for reversal of storage	NO	NO	NO	NO	NO
ICER replacement account for non-submission of certification report	NO	NO	NO	NO	NO
Total	NO	NO	NO	NO	NO

Table 12.21: SEF Table 5(a), Summary information on additions and subtractions (CP2)

	Additions					Subtractions						
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Assigned amount units issued	NO											
Article 3 Paragraph 7 ter cancellations						NO						
Cancellation following increase in ambition						NO						
Cancellation of remaining units after carry over							NO	NO	NO	NO	NO	NO
Non-compliance cancellation							NO	NO	NO	NO		
Carry-over		NO		NO				NO		NO		
Carry-over to PPSR	NO						NO					
Total	NO	NO		NO			NO	NO	NO	NO	NO	NO

Table 12.22: SEF Table 5(b), Summary information on annual transactions

	Additions					Subtractions						
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Year 1 (2013)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 2 (2014)	NO	NO	NO	130,870	NO	NO	NO	NO	NO	130,870	NO	NO
Year 3 (2015)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 4 (2016)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 5 (2017)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 6 (2018)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2019)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2020)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2021	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2022	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2023	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	NO	NO	NO	130,870	NO	NO	NO	NO	NO	130,870	NO	NO

Table 12.23: SEF Table 5(c), Summary information on annual transactions between PPSR accounts (CP2)

	Additions					Subtractions						
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Year 1 (2013)	NO						NO					
Year 2 (2014)	NO						NO					
Year 3 (2015)	NO						NO					
Year 4 (2016)	NO						NO					
Year 5 (2017)	NO						NO					
Year 6 (2018)	NO						NO					
Year 7 (2019)	NO						NO					
Year 8 (2020)	NO						NO					
2021	NO						NO					
2022	NO						NO					
2023	NO						NO					
Total	NO						NO					

Table 12.24: SEF Table 5(d), Summary information on expiry, cancellation and replacement (CP2)

	Requirement to replace or cancel					Replacement					Cancellation				
	tCERs	ICERs	CERs	AAUs	ERUs	RMUs	CERs	ICERs	tCERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Year 1 (2013)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 2 (2014)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 3 (2015)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 4 (2016)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 5 (2017)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 6 (2018)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2019)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2020)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2021	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2022	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2023	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 12.25: SEF Table 5(e), Summary information on retirement (CP2)

	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Year 1 (2013)	NO	NO	NO	NO	NO	NO
Year 2 (2014)	NO	NO	NO	NO	NO	NO
Year 3 (2015)	NO	NO	NO	NO	NO	NO
Year 4 (2016)	NO	NO	NO	NO	NO	NO
Year 5 (2017)	NO	NO	NO	NO	NO	NO
Year 6 (2018)	NO	NO	NO	NO	NO	NO
Year 7 (2019)	NO	NO	NO	NO	NO	NO
Year 8 (2020)	NO	NO	NO	NO	NO	NO
2021	NO	NO	NO	NO	NO	NO
2022	NO	NO	NO	NO	NO	NO
2023	NO	NO	NO	NO	NO	NO
Total	NO	NO	NO	NO	NO	NO

Table 12.26: SEF Table 6(a), Memo item: Corrective transactions relating to additions and subtractions

Additions						Subtractions					
AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs

Table 12.27: SEF Table 6 (b), Memo item: corrective transactions relating to replacement

Expiry, cancellation and requirement to replace		Replacement					
tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs

Table 12.28: SEF Table 6(c), Memo item: Corrective transactions relating to retirement (CP2)

Retirement					
AAUs	ERUs	RMUs	CERs	tCERs	ICERs

12.2 Discrepancies and notifications

Decision 15/CMP.1 annex I.E paragraphs 12-17, and draft decision FCCC/SBSTA/2014/L.29¹⁰, require Annex I Parties to report on various possible discrepancies and notifications. Australia's discrepancies and notifications are summarised in table 12.29.

Table 12.29: Accounting of Kyoto Protocol Units

Annual Submission Item	Report
Decision 15/CMP.1 annex I.E paragraph 11 and 19 as updated by draft decision FCCC/SBSTA/2014/L.29: Standard electronic format (SEF)	See section 12.1. The SEF tables have been submitted to the UNFCCC.
Decision 15/CMP.1 annex I.E paragraph 12: List of discrepant transaction	Australia had no transaction with discrepancies for the reporting period.
Decision 15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	Australia did not receive any CDM notifications.
Decision 15/CMP.1 annex I.E paragraph 15: List of non-replacements	Australia had no non-replacements.
Decision 15/CMP.1 annex I.E paragraph 16: List of invalid units	Australia had no invalid units.
Decision 15/CMP.1 annex I.E paragraph 17: Actions and changes to address discrepancies	None required.
Decision 15/CMP.1 annex I.E paragraph 18: Commitment period reserve calculation	See section 12.4

12.3 Publically accessible information

Public information is available <https://nationalregistry.cleanenergyregulator.gov.au/report/listPublicReports> under the Public Reports facility. Please note that personal information of Account Representatives, including their identification numbers, names, addresses, email and phone and fax numbers, is confidential and is not published, in accordance with decision 13/CMP.1 paragraph 44, draft decision FCCC/SBSTA/2014/L.29, and Regulation 50 of the *Australian National Registry of Emissions Units Regulations 2011*. A full description of the information that is available is in Annex 7.

12.4 Calculation of the Commitment Period Reserve

For the first commitment period, the Annex to decision 11/CMP.1 (paragraph 6) specified that: 'each Party included in Annex I shall maintain, in its national registry, a commitment period reserve which should not drop below 90 per cent of the Party's assigned amount calculated pursuant to Article 3, paragraphs 7 and 8 of the Kyoto Protocol, or 100 per cent of five times its most recently reviewed inventory, whichever is lowest'. Australia's commitment period reserve for the first commitment period was 2,661,821,229 tonnes CO₂ equivalent calculated as 90 per cent of Australia's assigned amount.

As set out in Annex 8 to this Report, Australia's commitment period reserve for CP2 is 4,041,254,030 tonnes CO₂ equivalent, calculated as 90 per cent of its assigned amount in accordance with decisions 11/CMP.1, 1/CMP.8 and 2/CMP.8 and draft decision FCCC/SBSTA/2014/L.29. This calculation is based on initial estimates of the KP CP2 assigned amount presented in Annex 8. These initial estimates, and the related

¹⁰ <http://unfccc.int/resource/docs/2014/sbsta/eng/l29.pdf>

commitment period reserve, were prepared in accordance with decision 1/CMP.8, and will constitute the Australian Government's submission of the report to facilitate the calculation of the assigned amount pursuant for the KP CP2 only at such time as the Australian Government ratifies the Doha Amendment¹¹.

12.5 KP-LULUCF Accounting

Australia has elected to account for the KP Article 3.3 LULUCF activities on an annual basis and to account for the Article 3.4 activities at the end of CP2. Table 12.30 shows the accounting quantities for 2013.

¹¹ Should Australia submit updated inventory data it will also update the base year and assigned amount estimates included in Annex 8 prior to the expert review of the Australian Government's submission of the report to facilitate the calculation of the assigned amount for KP CP2.

Table 12.30: Information table on accounting for activities under articles 3.3 and 3.4 of the Kyoto Protocol

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES		Base Year ²	NET EMISSIONS/REMOVALS		Accounting parameters	Accounting quantity ⁴
			2013	Total ³ (kt CO ₂ eq)		
A. Article 3.3 activities						
A.1. Afforestation/reforestation			-12,545	-12,545		-12,545
Excluded emissions from natural disturbances ⁵			NA	NA		
Excluded subsequent removals from land subject to natural disturbances ⁶			NA	NA		
A.2. Deforestation			37,190	37,190		37,190
B. Article 3.4 activities						
B.1. Forest management				-20,254		-21,371
Net emissions/removals			-11,315	-11,315		
Excluded emissions from natural disturbances ⁵			8,940	8,940		
Excluded subsequent removals from land subject to natural disturbances ⁶			NO	NO		
Any debits from newly established forest (CEF-ne) ^{7,8}			NA	NA		
Forest management reference level (FMRL) ⁹					4,724	
Technical corrections to FMRL ¹⁰					-3,608	
Forest management cap ¹¹						
B.2. Cropland management (if elected)		-68.73	-1,755	-1,755		1,685
B.3. Grazing land management (if elected)		-257	4,886	4,886		-5,143
B.4. Revegetation (if elected)		NA	NA	NA		NA
B.5. Wetland drainage and rewetting (if elected)		NA	NA	NA		NA

Notes for Table 12.30

- ¹ All values are reported in table 4(KP) and tables 4(KP-I).A.1.1, 4(KP-I).B.1.1, 4(KP-I).B.1.2 and 4(KP-I).B.1.3 of the CRF for the relevant inventory year as reported in the current submission and are automatically entered in this table.
- ² Net emissions and removals from cropland management, grazing land management, revegetation and/or wetland drainage and rewetting, if elected, in the Party's base year, as established by decision 9/CP.2.
- ³ Cumulative net emissions and removals for all years of the commitment period reported in the current submission.
- ⁴ The accounting quantity is the total quantity of units to be added to or subtracted from a Party's assigned amount for a particular activity in accordance with the provisions of Article 7.4 of the Kyoto Protocol.
- ⁵ A Party that has indicated their intent to apply the natural disturbance provisions may choose to exclude emissions from natural disturbances either annually or at the end of the commitment period.
- ⁶ Any subsequent removals on lands from which emissions from natural disturbances have been excluded is subtracted from the accounting quantity of the respective activity.
- ⁷ A debit is generated in case the newly established forest does not reach at least the expected carbon stock at the end of the normal harvesting period. Total debits from carbon equivalent forests are subtracted from the accounting quantity forest management.
- ⁸ In case of a projected forest management reference level, Parties should not fill in this row.
- ⁹ Forest management reference level as inscribed in the appendix of the annex to decision 2/CMP.7, in kt CO₂-e per year.
- ¹⁰ Technical corrections in accordance with paragraphs 14 and 15 of the annex to decision 2/CMP.7 and reported in table 4(KP-I) B.1.1 in kt CO₂-e per year.
- ¹¹ For the second commitment period, additions to the assigned amount of a Party resulting from forest management shall, in accordance with paragraph 13 of the annex to decision 2/CMP.7, not exceed 3.5 per cent of the national total emissions excluding LULUCF in the base year times eight.

13. Changes to the National System

Under the KP, decision 15/CMP.1 annex I.F paragraph 21 and draft decision FCCC/SBSTA/2014/L.29¹² requires Parties to include in the Report information on any changes that have occurred in its national system compared with its last submission.

Since the 2014 inventory submission there have been some changes to the arrangements for the QA/QC activities undertaken (see table 13.1 for more details).

Table 13.1: Change to the national system

Reporting Item	Annual Report
Decision 15/CMP.1 annex II.D paragraph 30 (a) Change of name or contact information	No change in this submission.
Decision 15/CMP.1 annex II.D paragraph 30 (b) Change of roles and responsibilities as well as change of the institutional, legal and procedural arrangements	No change in this submission.
Decision 15/CMP.1 annex II.D paragraph 30 (c) Changes in the process of inventory compilation	Continuing on from the improvements in the 2011-2014 submissions the process of inventory compilation continues to incorporate more facility specific data obtained under the NGER System. Recalculations flowing from the change have been identified in the relevant chapters of the Report.
Decision 15/CMP.1 annex II.E paragraph 30 (d) Change of process for key category identification and archiving	No change in this submission.
Decision 15/CMP.1 annex II.D paragraph 30 (e) Change of process for recalculations	No change in this submission.
Decision 15/CMP.1 annex II.D paragraph 30 (f) Changes with regard to QA/QC plan, QA/QC activities and procedures	Since the 2014 inventory submission additional QA/QC activities and procedures have been implemented as identified in the relevant chapters of the Report.
Decision 15/CMP.1 annex II.D paragraph 30 (g) Change of procedures for the official consideration and approval of the inventory	No change in this submission.

¹² <http://unfccc.int/resource/docs/2014/sbsta/eng/l29.pdf>

14. Changes to the National Registry

Under the KP, Parties are required to put in place a national registry to report annually on acquisition, holding, transfer, cancellation, withdrawal and carryover of assigned amount units, removal units, emission reduction units and certified emission reductions during the previous year. A full description of Australia's national registry system is presented in Annex 7. Australia's national registry is referred to as the Australian National Registry of Emissions Units (ANREU).

Decision 15/CMP.1 annex I.G paragraph 22 and draft decision FCCC/SBSTA/2014/L.29¹³ requires Parties to include in the Report information on any changes that have occurred in its national registry compared with its last submission.

Table 14.1: Change to the national registry

Reporting Item	Annual Report
Decision 15/CMP.1 annex II.E paragraph 32 (a) Change of name or contact	No change in this submission.
Decision 15/CMP.1 annex II.E paragraph 32 (b) Change of cooperation arrangement	No change in this submission.
Decision 15/CMP.1 annex II.E paragraph 32 (c) Change to database or the capacity of National Registry	Version 2.0 of the ANREU was released into production December 2013. In addition to the new software version, Australia has changed its hosting arrangements for the ANREU. This change resulted in a physical move of the ANREU infrastructure, as well as revised maintenance and support arrangements. Functionality to support the Data Exchange Standards (DES) requirements remains unchanged. As part of the infrastructure upgrade Australia has updated its database management software from Microsoft SQL 2008 to Microsoft SQL 2012.
Decision 15/CMP.1 annex II.E paragraph 32 (d) Change of conformance to technical standards	No change in this submission. The ANREU web application is based on the RIDGE platform which retains, at a minimum, the same level of conformance to technical standards as the previous version of the ANREU. In addition, the ANREU fully supports the revised transaction message flows specified by the current version of the DES for Registry Systems under the Kyoto Protocol. As well as this, the ANREU is equipped to handle transactions and reconciliation events involving "large" numbers of unit blocks as verified during the coordinated large unit block testing with the International Transaction Log (ITL).
Decision 15/CMP.1 annex II.E paragraph 32 (e) Change of discrepancies procedures	No change in this submission.
Decision 15/CMP.1 annex II.E paragraph 32 (f) Change of Security	Due to changes in the ANREU hosting arrangements revised ITL readiness documentation has been submitted to the ITL Administration team. A revised "Security Plan" outlining these new arrangements was submitted as part of this process. New security roles were also defined and released. The new roles (IT Administrator and Business Administrator) were created to reduce the number of system administrators with full access to the ANREU.

¹³ <http://unfccc.int/resource/docs/2014/sbsta/eng/l29.pdf>

Reporting Item	Annual Report
Decision 15/CMP.1 annex II.E paragraph 32 (g) Change of list of publicly available information	No change in this submission. Personal information of Account Representatives, including their identification numbers, names, addresses, email and phone and fax numbers, is confidential and is not published, in accordance with decision 13/CMP.1 annex paragraph 44, draft decision FCCC/SBSTA/2014/L.29, and Regulation 50 of the <i>Australian National Registry of Emissions Units Regulations 2011</i> . The non-confidential public information can now be found at https://nationalregistry.cleanenergyregulator.gov.au/report/listPublicReports under the Public Reports facility.
Decision 15/CMP.1 annex II.E paragraph 32 (h) Change of Internet address	No change in this submission. Australia's national registry can be found at https://nationalregistry.cleanenergyregulator.gov.au/ .
Decision 15/CMP.1 annex II.E paragraph 32 (i) Change of data integrity measure	No change in this submission.
Decision 15/CMP.1 annex II.E paragraph 32 (j) Change of test results	As part of the new ANREU hosting arrangements Australia has undertaken revised "Annex H" testing (December 2013). Functionality to support the DES requirements however remains unchanged.
Response to previous Annual Review recommendations	No issues were identified through the 2014 Standard Independent Annual Review (SIAR) process.

15. Minimization of Adverse Impacts in Accordance with Article 3.14

Australia is pleased to provide an update to its last submission and supplementary information on how Australia is striving, under Article 3, paragraph 14, of the KP, to implement its greenhouse gas emission limitation and reduction commitments in such a way as to minimize adverse social, environmental and economic impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9, of the UNFCCC.

Australia is committed to action on climate change as it recognizes that the cost of climate action is lower than the cost of inaction. Curbing emissions and reducing the impact of climate change will have substantial economic, social and environmental benefits, particularly for developing countries that are most vulnerable to climate impacts.

Australia is committed to taking cost-effective and practical steps to reduce Australia's emissions by five per cent on 2000 levels by 2020. The Government's Direct Action Plan will efficiently and effectively source low-cost emissions reductions within Australia. The central measure of this plan, the Emissions Reduction Fund, will create incentives for Australian businesses to improve their productivity and reduce their energy costs, while also reducing their emissions. Australia also supports international initiatives to advance practical climate action consistent with continued economic growth.

Australia recognizes that climate change, and measures to address climate change, can have social, environmental and economic impacts. Australia is striving to minimize any negative impacts in a number of ways:

1. In the development of policy, the Australian Government undertakes impact assessments as a matter of course, including consultation processes that enable those potentially affected to raise concerns.
2. Australia engages in international platforms such as the UNFCCC Forum on the Impact of Response Measures, which improve understanding of positive and negative impacts and let countries raise concerns and suggest ways to minimize adverse impacts.
3. Australia helps to minimize the adverse effects of climate change on vulnerable countries through adaptation support, to build countries' resilience to climate-related shocks and help countries manage climate change impacts in ways that support their economic development.
4. Australia is helping developing countries prepare for the global shift to lower emissions economies through efforts to develop and deploy low emissions technologies in developing countries. For example, Australia is supporting the United Nations Development Programme's Low Emissions Capacity Building Programme, green growth research and planning initiatives such as the Global Green Growth Institute, and technology partnerships such as the Australia-China Joint Coordination Group on Clean Coal Technology.
5. Australia's Aid for Trade program is helping developing countries reduce trade constraints, supporting their participation in the global trading system. This will help developing countries build the economic resilience necessary to adjust to the impacts of climate change and response measures.
6. Australia is working with several countries in the World Trade Organization to negotiate an agreement to eliminate tariffs on goods that promote sustainable development. This includes renewable energy equipment and products with genuine energy efficiency benefits. This negotiation has the potential to significantly boost the economics of low emissions technologies globally.

ANNEX 1: Key category Analysis

A1.1 Convention Accounting

A *key category* has a significant influence on a country's total inventory of direct greenhouse gases in terms of absolute level of emissions, the trend in emissions, or both. Australia has identified the key sources for the UNFCCC inventory using the tier 1 level and trend assessments as recommended in the 2006 IPCC *Good Practice for National Greenhouse Gas Inventories* (IPCC 2006). This approach identifies sources that contribute to 95% of the total emissions or 95% of the trend of the inventory in absolute terms.

When the LULUCF sector is included in the analysis, Australia has identified *public electricity (solid fuel)*, *road transportation (liquid fuels)* and *land converted* to grassland as the most significant of the key categories (i.e. contributing more than 10% of the level or trend) in 2013. The full results for the 2013 key source analysis are reported in Tables A.1.1 to A.1.3.

When the LULUCF sector is excluded from the analysis the most significant key categories in 2013 are public electricity (solid fuel), road transportation (liquid fuels) and enteric fermentation (sheep). The results of this latter analysis are presented in Tables A.1.4 to A.1.6. Table A.1.7 summarises the results of the key category analysis for LULUCF categories under KP accounting.

The Australian analysis has been undertaken using a relatively high degree of disaggregation of sources, which permits a greater degree of understanding of Australia's key categories. Past analyses by the UNFCCC secretariat of Australian data, using higher levels of aggregation common in the analyses undertaken by other countries, have not produced any important distinctions.

A1.2 Kyoto Protocol LULUCF Activities

The KP-LULUCF key categories have been identified using the method documented in section 2.3.6 of IPCC 2014. The results are presented in Table A.1.7.

Table A1.1: Key categories for Australia's 2013 inventory-level assessment including LULUCF

A		B	C	D	E	F
IPCC Source Category		Gas	Base Year Estimate	Current Year Estimate	Level Assessment	Cumulative Total
1.A.1.A	Public Electricity and Heat Production \ Solid Fuels	CO ₂	117,909	156,774	0.24	0.24
1.A.3.B	Road Transportation \ Liquid Fuels	CO ₂	52,378	75,977	0.11	0.35
3.A.1	Enteric Fermentation \ Cattle	CH ₄	36,456	43,476	0.07	0.41
4.C.2	Land converted to Grassland	CO ₂	121,099	36,521	0.05	0.47
1.A.1.A	Public Electricity and Heat Production \ Gaseous Fuels	CO ₂	8,281	26,626	0.04	0.51
4.A.1	Forest Land remaining Forest Land	CO ₂	29,868	25,799	0.04	0.55
1.B.1.A.1.1	Underground Mines \ Mining Activities	CH ₄	16,605	17,254	0.03	0.57
4.A.2	Land converted to Forest Land	CO ₂	1,513	12,932	0.02	0.59
3.A.2	Enteric Fermentation \ Sheep	CH ₄	30,128	12,580	0.02	0.61
5.A.1	Managed Waste Disposal	CH ₄	16,269	10,394	0.02	0.63
2.F.1	Refrigeration and air-conditioning	HFC	0	9,670	0.01	0.64
1.A.1.C	Manufacture of Solid Fuels and Other Energy Industries \ Gaseous Fuels	CO ₂	4,577	8,901	0.01	0.66
1.A.3.A	Domestic Aviation	CO ₂	2,615	8,039	0.01	0.67
1.A.4.B	Residential \ Gaseous Fuels	CO ₂	4,646	7,962	0.01	0.68
1.A.1.C	Manufacture of Solid Fuels and Other Energy Industries \ Liquid Fuels	CO ₂	968	7,712	0.01	0.69
1.A.2.B	Non-Ferrous Metals \ Gaseous Fuels	CO ₂	4,170	7,517	0.01	0.70
1.A.2.F	Other (please specify) \ Mining \ Liquid Fuels	CO ₂	1,759	7,466	0.01	0.71
3.E	Prescribed Burning of Savannas	CH ₄	4,460	6,868	0.01	0.72
2.C.1.d	Coke	CO ₂	9,203	6,679	0.01	0.73
1.A.4.C	Agriculture/Forestry/Fisheries \ Liquid Fuels	CO ₂	3,406	6,287	0.01	0.74
1.B.1.A.2.1	Surface Mining\ Mining Activities	CH ₄	3,351	5,387	0.01	0.75
2.F.1	Refrigeration and air-conditioning	HFC-134a	-	5,323	0.01	0.76
2.F.1	Refrigeration and air-conditioning	HFC-134a	-	5,177	0.01	0.77
1.A.2.C	Chemicals \ Liquid Fuels	CO ₂	3,297	4,891	0.01	0.78
1.A.2.B	Non-Ferrous Metals \ Solid Fuels	CO ₂	4,132	4,406	0.01	0.78
1.A.1.B	Petroleum Refining \ Liquid Fuels		3,263	3,904	0.01	0.82
1.A.2.B	Non-Ferrous Metals \ Liquid Fuels	CO ₂	2,849	4,127	0.01	0.79
3.D.a.4	Agricultural Soil \ Direct Soil Emissions \ Crop Residue	N ₂ O	2,878	4,071	0.01	0.80
4.G	Harvested Wood Products	CO ₂	4,209	3,842	0.01	0.81
1.B.2.C.1.2	Fugitives\Venting and Flaring\ Venting\Gas	CO ₂	1,966	3,640	0.01	0.81
4.B.2	Land converted to Cropland	CO ₂	9,178	3,534	0.01	0.82

A		B	C	D	E	F
IPCC Source Category		Gas	Base Year Estimate	Current Year Estimate	Level Assessment	Cumulative Total
3.D.a.3	Agricultural Soils \ Direct Soil Emissions \ Urine and Dung Deposited by Grazing Animals	N ₂ O	4,434	3,427	0.01	0.82
2.A.1	Cement Industry	CO ₂	3,463	3,294	0.00	0.83
1.A.2.C	Chemicals \ Gaseous Fuels	CO ₂	1,452	3,261	0.00	0.83
2.C.3	Aluminium Production	CO ₂	2,058	3,071	0.00	0.84
1.A.3.C	Railways \ Liquid Fuels	CO ₂	1,734	3,001	0.00	0.84
1.A.2.F	Other (please specify) \ Mineral industry \ Gaseous Fuels	N ₂ O	2,972	2,955	0.00	0.85
4.C.1	Grassland remaining Grassland	CO ₂	3,952	2,685	0.00	0.85
1.A.1.A	Public Electricity and Heat Production \ Liquid Fuels	CO ₂	2,907	2,631	0.00	0.85
1.A.4.A	Commercial/Institutional \ Gaseous Fuels	CO ₂	1,824	2,507	0.00	0.86
1.B.2.C.2	Fugitives \ Venting and Flaring, \ Flaring \ Gas	CO ₂	3,601	2,485	0.00	0.86
3.D.a.1	Agricultural Soils \ Direct Soil Emissions \ Inorganic Fertilisers	N ₂ O	1,332	2,364	0.00	0.86
1.B.2.B.5	Fugitive Emissions From Fuels, Oil and Natural Gas, Natural Gas, Distribution	CH ₄	4,316	2,316	0.00	0.87
2.B	Chemicals	CO ₂	603	2,290	0.00	0.87
4.B.1	Cropland remaining Cropland	CO ₂	69	2,216	0.00	0.88
1.A.2.F	Non-Metallic Minerals \ Mineral industry \ Solid Fuels	CO ₂	2,212	2,189	0.00	0.88
1.A.4.A	Commercial/Institutional \ Liquid Fuels	CO ₂	1,246	2,130	0.00	0.88
3.D.b.2	Agricultural Soils \ Indirect Soil Emissions \ Nitrogen Leaching and Run-Off	CO ₂	1,921	2,098	0.00	0.88
2.B	Chemicals	CO ₂	995	1,921	0.00	0.89
1.A.2.E	Food Processing, Beverages and Tobacco \ Gaseous Fuels	CO ₂	1,255	1,803	0.00	0.89
1.A.3.D	Domestic navigation \ Liquid Fuels	CO ₂	2,469	1,802	0.00	0.89
2.A.3	Other process uses of carbonates	CO ₂	1,252	1,549	0.00	0.90
1.A.2.F	Other (please specify) \ Construction \ Liquid Fuels	CO ₂	2,838	1,502	0.00	0.90
1.A.3.B	Road Transportation \ Liquid Fuels	CO ₂	663	1,302	0.00	0.90
1.A.4.B	Residential \ Liquid Fuels	CO ₂	1,320	1,295	0.00	0.90
2.A.2	Lime Production	CO ₂	775	1,257	0.00	0.90
3.B.3	Manure Management \ Swine	CO ₂	1,546	1,192	0.00	0.91
1.B.1.A.1	Fugitives \ Solid fuels \ Underground Mines	CO ₂	1,122	1,177	0.00	0.91
3.B.1	Manure Management \ Cattle	CH ₄	497	1,146	0.00	0.91
4.C.1	Grassland remaining Grassland	N ₂ O	3,068	1,113	0.00	0.92

A		B	C	D	E	F
IPCC Source Category		Gas	Base Year Estimate	Current Year Estimate	Level Assessment	Cumulative Total
1.B.1.A.1.2	Fugitives \ Solid Fuel\ Underground Mines\ Post-Mining Activities	CH ₄	566	1,090	0.00	0.92
1.AA.2.F	Manufacturing Industries and Construction Other \ Gaseous	CO ₂	1,110	1,081	0.00	0.92
1.B.2.B.1	Natural Gas Exploration	CH ₄	133	1,031	0.00	0.92
5.D.1	Domestic Wastewater	CH ₄	1,771	1,002	0.00	0.92
1.AA.2.A	Manufacturing Industries and Construction Iron and Steel \ Solid	CO ₂	1,206	994	0.00	0.92
1.AA.2.E	Manufacturing Industries and Construction Food Processing, Beverages and Tobacco \ Solid	CO ₂	1,214	987	0.00	0.93
1.AA.2.D	Manufacturing Industries and Construction Pulp, Paper and Print \ Gaseous	CO ₂	823	973	0.00	0.93
1.AA.2.A	Manufacturing Industries and Construction Iron and Steel \ Gaseous	CO ₂	1,393	959	0.00	0.93
1.AA.3.E	Other Transportation \ Gaseous	CO ₂	262	937	0.00	0.93
4.C.2	Land converted to Grassland	CH ₄	4,009	876	0.00	0.93
4.C.2.1	Forest Land converted to Grassland	CH ₄	4,009	876	0.00	0.93
1.A.5	Other (not elsewhere classified) \ Mobile Liquid	CO ₂	424	872	0.00	0.93
1.B.2.C.1.2	Fugitives\Venting and Flaring\ Venting\Gas	CH ₄	2,064	858	0.00	0.93
2.B	Chemicals	CO ₂	415	850	0.00	0.94
1.AA.1.A	Energy Industries Public Electricity and Heat Production Solid	N ₂ O	340	781	0.00	0.94
3.C.2	Liming	CO ₂	170	761	0.00	0.94
1.AA.1.B	Energy Industries Petroleum Refining Gaseous	CO ₂	581	708	0.00	0.94
1.AA.2.	Manufacturing Industries and Construction Non-Metallic Minerals\ Liquid	CO ₂	317	694	0.00	0.94
3.D.b.1	Agricultural Soils \ Indirect Soil Emissions \ Atmospheric Deposition	N ₂ O	647	668	0.00	0.94
3.B.1	Manure Management Cattle	N ₂ O	258	601	0.00	0.94
1.A.3.A	Domestic Aviation \ Solid	CO ₂	313	571	0.00	0.94
3.C	Rice Cultivation	CH ₄	562	556	0.00	0.94
1.B.1.A.1	Fugitives \ Solid fuels \ Underground Mines \ Abandoned Underground Mines	CH ₄	470	537	0.00	0.94
1.B.2.C.2.1	Fugitives \ Venting and Flaring \ Flaring \ Oil	CO ₂	-	524	0.00	0.95

Table A1.2: Key categories for Australia's 2013 inventory – trend assessment including LULUCF

A		B	C	D	E	F	G
IPCC Source Categories		Gas	Base Year Estimate	Current Year Estimate	Trend Assessment	% Contribution to Trend	Cumulative Total of Column F
4.C.2	Land converted to Grassland	CO ₂	121,099	36,521	0.14	0.21	0.21
1.A.1.A	Public Electricity and Heat Production \ Solid Fuels	CO ₂	117,909	156,774	0.10	0.15	0.36
1.A.3.B	Road Transportation \ Liquid Fuels	CO ₂	52,378	75,977	0.06	0.09	0.45
1.A.1.A	Public Electricity and Heat Production \ Gaseous Fuels	CO ₂	8,281	26,626	0.04	0.06	0.50
3.A.2	Enteric Fermentation \ Sheep	CH ₄	30,128	12,580	0.03	0.04	0.54
4.A.2	Land converted to Forest Land	CO ₂	1,513	12,932	0.03	0.04	0.59
3.A.1	Enteric Fermentation \ Cattle	CH ₄	36,456	43,476	0.02	0.03	0.62
2.F.1	Refrigeration and air-conditioning	HFC	-	9,670	0.02	0.03	0.65
1.A.1.C	Manufacture of Solid Fuels and Other Energy Industries \ Liquid Fuels	CO ₂	968	7,712	0.01	0.02	0.67
4.B	Cropland	CO ₂	9,110	1,318	0.01	0.02	0.69
1.A.2.F	Other (please specify) \ Mining \ Liquid Fuels	CO ₂	1,759	7,466	0.01	0.02	0.70
1.A.3.A	Domestic Aviation	CO ₂	2,615	8,039	0.01	0.02	0.72
2.F.1	Refrigeration and air-conditioning	HFC-134 _a	-	5,323	0.01	0.02	0.73
2.F.1	Refrigeration and air-conditioning	HFC-125	-	5,177	0.01	0.02	0.75
1.A.1.C	Manufacture of Solid Fuels and Other Energy Industries \ Gaseous Fuels	CO ₂	4,577	8,901	0.01	0.01	0.76
4.B.2	Land converted to Cropland	CO ₂	9,178	3,534	0.01	0.01	0.78
5.A.1	Managed Waste Disposal	CH ₄	16,269	10,394	0.01	0.01	0.79
1.A.4.B	Residential \ Gaseous Fuels	CO ₂	4,646	7,962	0.01	0.01	0.80
1.A.2.B	Non-Ferrous Metals \ Gaseous Fuels	CO ₂	4,170	7,517	0.01	0.01	0.81
1.A.4.C	Agriculture/Forestry/ Fisheries \ Liquid Fuels	CO ₂	3,406	6,287	0.01	0.01	0.82
2.C.3	Aluminium Production	CF ₄	3,794	163	0.01	0.01	0.83

A		B	C	D	E	F	G
IPCC Source Categories		Gas	Base Year Estimate	Current Year Estimate	Trend Assessment	% Contribution to Trend	Cumulative Total of Column F
3.E	Prescribed Burning of Savannas	CH ₄	4,460	6,868	0.01	0.01	0.84
1.B.1.a.i	Mining Activities	CH ₄	16,605	17,254	0.00	0.01	0.85
1.B.1.a.ii	Mining Activities	CH ₄	3,351	5,387	0.00	0.01	0.85
4.B.1	Cropland remaining Cropland	CO ₂	69	2,216	0.00	0.01	0.86
1.A.2.C	Chemicals \ Gaseous Fuels	CO ₂	1,452	3,261	0.00	0.01	0.87
1.A.2.C	Chemicals \ Liquid Fuels	CO ₂	3,297	4,891	0.00	0.01	0.87
1.B.2.c1	Venting	CO ₂	1,966	3,640	0.00	0.01	0.88
2.B	Chemical	CO ₂	603	2,290	0.00	0.01	0.88
1.A.1.C	Manufacture of Solid Fuels and Other Energy Industries \ Solid Fuels	CO ₂	2,397	401	0.00	0.01	0.89
1.A.2.B	Non-Ferrous Metals \ Liquid Fuels	CO ₂	2,849	4,127	0.00	0.00	0.89
2.C.1.d	Coke	CO ₂	9,203	6,679	0.00	0.00	0.90
1.B.2.B.4	Transmission and Storage	CH ₄	4,316	2,316	0.00	0.00	0.90
3.D.a.4	Agricultural Soil \ Direct Soil Emissions \ Crop Residue	N ₂ O	2,878	4,071	0.00	0.00	0.91
1.A.3.C	Railways \ Liquid Fuels	CO ₂	1,734	3,001	0.00	0.00	0.91
2.C.3	Aluminium Production	CO ₂	2,058	3,071	0.00	0.00	0.91
1.A.4.B	Residential \ Biomass	CH ₄	2,403	941	0.00	0.00	0.92
3.D.a.1	Agricultural Soils \ Direct Soil Emissions \ Inorganic Fertilisers	N ₂ O	1,332	2,364	0.00	0.00	0.92
1.A.2.F	Other (please specify) \ Construction \ Liquid Fuels	CO ₂	2,838	1,502	0.00	0.00	0.92
2.B	Chemical	N ₂ O	995	1,921	0.00	0.00	0.93
1.A.4.A	Commercial/ Institutional \ Liquid Fuels	CO ₂	1,246	2,130	0.00	0.00	0.93
1.B.2.C.1.2	Fugitives\Venting and Flaring\Venting\Gas	CH ₄	2,064	858	0.00	0.00	0.93
1.B.2.B.1	Fugitives\Oil and Natural Gas\Natural Gas\ Exploration	CH ₄	133	1,031	0.00	0.00	0.93
4.A.1	Forest Land remaining Forest Land	CO ₂	29,868	25,799	0.00	0.00	0.94
1.B.2.C.2.2	Fugitives \ Venting and Flaring \ Flaring \ Gas	CH ₄	1,124	110	0.00	0.00	0.94

Table A1.3: Key categories for Australia's 2013 inventory – summary including LULUCF

A		B	C	D
IPCC Source Categories		Direct Greenhouse Gas	Key Source Category Flag	If Column C is Yes, Criteria for Identification
1.A.1.a	Public Electricity and Heat Production \ Solid Fuels	CO ₂	YES	Level, Trend
1.A.1.a	Public Electricity and Heat Production \ Gaseous Fuels	CO ₂	YES	Level, Trend
1.A.1.a	Public Electricity and Heat Production \ Liquid Fuels	CO ₂	YES	Level
1.A.1.b	Petroleum Refining \ Liquid Fuels	CO ₂	YES	Level
1.A.1.b	Petroleum Refining \ Gaseous Fuels	CO ₂	YES	Level
1.A.1.c	Manufacture of Solid Fuels and Other Energy Industries \ Gaseous Fuels	CO ₂	YES	Level, Trend
1.A.1.c	Manufacture of Solid Fuels and Other Energy Industries \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.1.c	Manufacture of Solid Fuels and Other Energy Industries \ Solid Fuels	CO ₂	YES	Trend
1.A.2.a	Manufacturing Industries and Construction Non-Metallic Minerals Liquid	CO ₂	YES	Level
1.A.2.a	Manufacturing Industries and Construction Iron and Steel Solid	CO ₂	YES	Level
1.A.2.a	Manufacturing Industries and Construction Iron and Steel Gaseous	CO ₂	YES	Level
1.A.2.b	Non-Ferrous Metals \ Gaseous Fuels	CO ₂	YES	Level, Trend
1.A.2.b	Non-Ferrous Metals \ Solid Fuels	CO ₂	YES	Level
1.A.2.b	Non-Ferrous Metals \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.2.c	Chemicals \ Liquid Fuels	CO ₂	YES	Level
1.A.2.c	Chemicals \ Gaseous Fuels	CO ₂	YES	Level
1.A.2.d	Manufacturing Industries and Construction Pulp, Paper and Print Gaseous	CO ₂	YES	Level
1.A.2.e	Food Processing, Beverages and Tobacco \ Gaseous Fuels	CO ₂	YES	Level
1.A.2.e	Food Processing, Beverages and Tobacco \ Solid Fuels	CO ₂	YES	Level
1.A.2.f	Other (please specify) \ Mining \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.2.f	Other (please specify) \ Mineral industry \ Gaseous Fuels	CO ₂	YES	Level
1.A.2.f	Other (please specify) \ Mineral industry \ Solid Fuels	CO ₂	YES	Level
1.A.2.f	Other (please specify) \ Construction \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.3.a	Domestic Aviation \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.3.a	Domestic aviation \ Solid Fuels	CO ₂	YES	Level
1.A.3.b	Road Transportation \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.3.b	Road Transportation \ Liquid Fuels	CO ₂	YES	Level
1.A.3.c	Railways \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.3.d	Navigation \ Liquid Fuels	CO ₂	YES	Level
1.A.3.e	Other Transportation Gaseous	CO ₂	YES	Level

A		B	C	D
IPCC Source Categories		Direct Greenhouse Gas	Key Source Category Flag	If Column C is Yes, Criteria for Identification
1.A.4.a	Commercial/Institutional \ Gaseous Fuels	CO ₂	YES	Level
1.A.4.a	Commercial/Institutional \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.4.b	Residential \ Liquid Fuels	CO ₂	YES	Level
1.A.4.b	Residential \ Gaseous Fuels	CO ₂	YES	Level, Trend
1.A.4.b	Residential \ Biomass	CH ₄	YES	Trend
1.A.4.c	Agriculture/Forestry/Fisheries \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.5	Mobile Liquid	CO ₂	YES	Trend
1.B.1.A.1.1	Underground Mines \ Mining Activities	CH ₄	YES	Level, Trend
1.B.1.A.2.1	Surface Mining \ Mining Activities	CH ₄	YES	Level, Trend
1.B.1.A.2.1	Surface Mining \ Mining Activities	CO ₂	YES	Level, Trend
1.B.1.A.1.2	Solid Fuel \ Underground Mines \ Post-Mining Activities	CO ₂	YES	Level
1.B.2.B.1	Fugitives \ Natural Gas \ Exploration	CH ₄	YES	Level, Trend
1.B.2.B.5	Fugitive Emissions From Fuels, Oil and Natural Gas, Natural Gas, Distribution	CH ₄	YES	Level, Trend
1.B.2.C.1.2	Fugitives \ Venting and Flaring \ Venting \ Gas	CO ₂	YES	Level, Trend
1.B.2.C.1.2	Fugitives \ Venting and Flaring \ Venting \ Gas	CH ₄	YES	Level, Trend
1.B.2.C.2.1	Fugitives \ Venting and Flaring \ Flaring \ Oil	CH ₄	YES	Level
1.B.2.C.2.2	Fugitives \ Venting and Flaring \ Flaring \ Gas	CO ₂	YES	Level
1.B.2.C.2.2	Fugitives \ Venting and Flaring \ Flaring \ Gas	CH ₄	YES	Trend
2.A.1	Cement Production	CO ₂	YES	Level
2.A.2	Lime Production	CO ₂	YES	Level
2.A.3	Glass Production	CO ₂	YES	Level
2.B	Chemicals	CO ₂	YES	Level
2.B	Chemicals	CO ₂	YES	Level, Trend
2.B	Chemicals	N ₂ O	YES	Level, Trend
2.C.1.d	Iron and Steel \ Coke	CO ₂	YES	Level, Trend
2.C.3	Aluminium Production	CO ₂	YES	Level, Trend
2.C.3	Aluminium Production	CF ₄	YES	Trend
2.F.1	Refrigeration and Air Conditioning Equipment	HFC	YES	Level, Trend
2.F.1	Refrigeration and Air Conditioning Equipment	HFC-134a	YES	Level, Trend
2.F.1	Refrigeration and Air Conditioning Equipment	HFC-125	YES	Level, Trend
3.A.1	Enteric Fermentation \ Cattle	CH ₄	YES	Level, Trend
4.A.2	Enteric Fermentation \ Sheep	CH ₄	YES	Level, Trend
3.B.1	Manure Management Cattle	CH ₄	YES	Level
3.B.1	Manure Management Cattle	N ₂ O	YES	Level
3.B.3	Manure Management \ Swine	CH ₄	YES	Level
3.C	Rice Cultivation	CH ₄	YES	Level
3.C.2	Liming	CO ₂	YES	Level
3.D.a.1	Agricultural Soils \ Direct Soil Emissions \ Inorganic Fertilisers	N ₂ O	YES	Level, Trend

A		B	C	D
IPCC Source Categories		Direct Greenhouse Gas	Key Source Category Flag	If Column C is Yes, Criteria for Identification
3.D.a.3	Agricultural Soils \ Direct Soil Emissions \ Urine and Dung Deposited by Grazing Animals	N ₂ O	YES	Level
3.D.a.4	Agricultural Soil \ Direct Soil Emissions \ Crop Residue	N ₂ O	YES	Level, Trend
3.D.b.1	Atmospheric Deposition	N ₂ O	YES	Level
3.D.b.2	Nitrogen Leaching and Run-off	N ₂ O	YES	Level
5(V)	Forest Land remaining Forest Land \ Biomass Burning \ Wildfires	CH ₄	YES	Level, Trend
6.A.1	Managed Waste Disposal on Land	CH ₄	YES	Level, Trend
6.B.1	Industrial Wastewater \ Wastewater	CH ₄	YES	Trend
3.E	Prescribed Burning of Savannas	CH ₄	YES	Level, Trend
3.E	Prescribed Burning of Savannas	N ₂ O	YES	Level
3.H	Urea Application	CO ₂	YES	Level
4.A.1	Forest Land remaining Forest Land	CO ₂	YES	Level, Trend
4.A.1	Forest Land remaining Forest Land	CH ₄	YES	Level, Trend
4.A.2	Land converted to Forest Land	CO ₂	YES	Level, Trend
4.B.1	Cropland remaining Cropland	CO ₂	YES	Level
4.B.2	Land converted to Cropland	CO ₂	YES	Level, Trend
4.C.1	Grassland remaining Grassland	CO ₂	YES	Level, Trend
4.C.1	Grassland remaining Grassland	N ₂ O	YES	Level
4.C.2	Land converted to Grassland	CO ₂	YES	Level, Trend
4.C.2	Land converted to Grassland	CH ₄	YES	Trend
4.C.2.1	Forest Land converted to Grassland	CH ₄	YES	Level
4.G	Other (Harvested Wood Products)	CO ₂	YES	Level
5.A.1	Managed Waste Disposal	CH ₄	YES	Level, Trend
5.D.1	Domestic Wastewater	CH ₄	YES	Level

Table A1.4: Key categories for Australia's 2013 inventory-level assessment excluding LULUCF

A		B	C	D	E	F
IPCC Source Category		Gas	Base Year Estimate	Current Year Estimate	Level Assessment	Cumulative Total
1.A.1.A	Public Electricity and Heat Production \ Solid Fuels	CO ₂	117,909	156,774	0.29	0.29
1.A.3.B	Road Transportation \ Liquid Fuels	CO ₂	52,378	75,977	0.14	0.43
3.A.1	Enteric Fermentation \ Cattle	CH ₄	36,456	43,476	0.08	0.51
1.A.1.A	Public Electricity and Heat Production \ Gaseous Fuels	CO ₂	8,281	26,626	0.05	0.56
1.B.1.A.1.1	Underground Mines \ Mining Activities	CH ₄	16,605	17,254	0.03	0.59
3.A.2	Enteric Fermentation \ Sheep	CH ₄	30,128	12,580	0.02	0.61
5.A.1	Managed Waste Disposal	CH ₄	16,269	10,394	0.02	0.63
2.F.1	Refrigeration and air-conditioning	HFC	-	9,670	0.02	0.65
1.A.1.C	Manufacture of Solid Fuels and Other Energy Industries \ Gaseous Fuels	CO ₂	4,577	8,901	0.02	0.67
1.A.3.A	Domestic Aviation	CO ₂	2,615	8,039	0.01	0.68
1.A.4.B	Residential \ Gaseous Fuels	CO ₂	4,646	7,962	0.01	0.70
1.A.1.C	Manufacture of Solid Fuels and Other Energy Industries \ Liquid Fuels	CO ₂	968	7,712	0.01	
0.71	Civil Aviation \ Liquid Fuels	CO ₂	2,588	7,368	0.01	0.74
1.A.2.B	Non-Ferrous Metals \ Gaseous Fuels	CO ₂	4,170	7,517	0.01	0.72
1.A.2.F	Other (please specify) \ Mining \ Liquid Fuels	CO ₂	1,759	7,466	0.01	0.74
3.E	Prescribed Burning of Savannas	CH ₄	4,460	6,868	0.01	0.75
2.C.1.d	Iron and Steel Production, Other	CO ₂	9,203	6,679	0.01	0.76
1.A.4.C	Agriculture/Forestry/ Fisheries \ Liquid Fuels	CO ₂	3,406	6,287	0.01	0.78
1.B.1.A.2.1	Surface Mining \ Mining Activities	CH ₄	3,351	5,387	0.01	0.78
2.F.1	Refrigeration and air-conditioning	HFC-134a	-	5,323	0.01	0.79
2.F.1	Refrigeration and air-conditioning	HFC-125	-	5,177	0.01	0.80
1.A.2.C	Chemicals \ Liquid Fuels	CO ₂	3,297	4,891	0.01	0.81
1.A.2.B	Non-Ferrous Metals \ Solid Fuels	CO ₂	4,132	4,406	0.01	0.82
1.A.1.B	Petroleum Refining \ Liquid Fuels	CO ₂	4,931	4,314	0.01	0.83
1.A.2.B	Non-Ferrous Metals \ Liquid Fuels	CO ₂	2,849	4,127	0.01	0.84
3.D.a.4	Agricultural Soil \ Direct Soil Emissions \ Crop Residue	N ₂ O	2,878	4,071	0.01	0.84
1.B.2.C.1.2	Fugitives \ Venting and Flaring \ Venting \ Gas	CO ₂	1,966	3,640	0.01	0.85
3.D.a.3	Agricultural Soils \ Direct Soil Emissions \ Urine and Dung Deposited by Grazing Animals	N ₂ O	4,434	3,427	0.01	0.86
2.A.1	Cement Industry	CO ₂	3,463	3,294	0.01	0.86

A		B	C	D	E	F
IPCC Source Category		Gas	Base Year Estimate	Current Year Estimate	Level Assessment	Cumulative Total
1.A.2.C	Chemicals \ Gaseous Fuels	CO ₂	1,452	3,261	0.01	0.87
2.C.3	Aluminium Production	CO ₂	2,058	3,071	0.01	0.88
1.A.3.C	Railways \ Liquid Fuels	CO ₂	1,734	3,001	0.01	0.88
1.A.2.F	Other (please specify) \ Mineral industry \ Gaseous Fuels	CO ₂	2,972	2,955	0.01	0.89
1.A.1.A	Public Electricity and Heat Production \ Liquid Fuels	CO ₂	2,907	2,631	0.00	0.89
1.A.4.A	Commercial/Institutional \ Gaseous Fuels	CO ₂	1,824	2,507	0.00	0.90
1.B.2.C.2	Fugitives\Venting and Flaring, \ Flaring \Gas	CO ₂	3,601	2,485	0.00	0.90
3.D.a.1	Agricultural Soils \ Direct Soil Emissions \ Inorganic Fertilisers	N ₂ O	1,332	2,364	0.00	0.90
3.E	Prescribed Burning of Savannas	N ₂ O	1,205	2,331	0.00	0.91
1.B.2.B.5	Fugitive Emissions From Fuels, Oil and Natural Gas, Natural Gas, Distribution	CH ₄	4,316	2,316	0.00	0.91
2.B	Chemical	CO ₂	603	2,290	0.00	0.92
1.A.2.F	Other (please specify) \ Mineral industry \ Solid Fuels	CO ₂	2,212	2,189	0.00	0.92
1.A.4.A	Commercial/Institutional \ Liquid Fuels	CO ₂	1,246	2,130	0.00	0.93
3.D.b.2	Agricultural Soils \ Indirect Soil Emissions \ Nitrogen Leaching and Run-Off	N ₂ O	1,921	2,098	0.00	0.93
2.B	Chemicals	N ₂ O	995	1,921	0.00	0.93
1.A.2.E	Food Processing, Beverages and Tobacco \ Gaseous Fuels	CO ₂	1,255	1,803	0.00	0.94
1.A.3.D	Domestic navigation \ Liquid Fuels	CO ₂	2,469	1,802	0.00	0.94
2.A.3	Other process uses of carbonates	CO ₂	1,252	1,549	0.00	0.94
1.A.2.F	Other (please specify) \ Construction \ Liquid Fuels	CO ₂	2,838	1,502	0.00	0.94
1.A.3.B	Road Transportation \ Liquid Fuels	N ₂ O	663	1,302	0.00	0.95

Table A1.5: Key categories for Australia's 2013 inventory – trend assessment excluding LULUCF

A		B	C	D	E	F	G
IPCC Source Categories		Gas	Base Year Estimate	Current Year Estimate	Trend Assessment	% Contribution to Trend	Cumulative Total of Column F
3.A.2	Enteric Fermentation \ Sheep	CH ₄	30,128	12,580	0.04	0.14	0.14
1.A.1.A	Public Electricity and Heat Production \ Gaseous Fuels	CO ₂	8,281	26,626	0.02	0.09	0.23
5.A.1	Managed Waste Disposal	CH ₄	16,269	10,394	0.02	0.06	0.29
2.F.1	Refrigeration and air-conditioning	HFC	-	9,670	0.01	0.05	0.34
1.A.3.B	Road Transportation \ Liquid Fuels	CO ₂	52,378	75,977	0.01	0.04	0.38
1.A.1.C	Manufacture of Solid Fuels and Other Energy Industries \ Liquid Fuels	CO ₂	968	7,712	0.01	0.04	0.42
2.F.1	Refrigeration and air-conditioning	HFC-134a	-	5,323	0.01	0.03	0.45
2.C.1.d	Coke	CO ₂	9,203	6,679	0.01	0.03	0.48
1.A.2.F	Other (please specify) \ Mining \ Liquid Fuels	CO ₂	1,759	7,466	0.01	0.03	0.51
2.F.1	Refrigeration and air-conditioning	HFC-125	-	5,177	0.01	0.03	0.53
2.C.3	Aluminium Production	CF ₄	3,794	163	0.01	0.03	0.56
1.A.3.A	Domestic Aviation	CO ₂	2,615	8,039	0.01	0.03	0.58
1.B.1.A.1.1	Underground Mines \ Mining Activities	CH ₄	16,605	17,254	0.01	0.02	0.61
3.A.1	Enteric Fermentation \ Cattle	CH ₄	36,456	43,476	0.01	0.02	0.63
1.A.1.A	Public Electricity and Heat Production \ Solid Fuels	CO ₂	117,909	156,774	0.01	0.02	0.65
1.B.2.B.5	Fugitive Emissions From Fuels, Oil and Natural Gas, Natural Gas, Distribution	CH ₄	4,316	2,316	0.00	0.02	0.67
1.A.1.C	Manufacture of Solid Fuels and Other Energy Industries \ Gaseous Fuels	CO ₂	4,577	8,901	0.00	0.02	0.68
1.A.1.C	Manufacture of Solid Fuels and Other Energy Industries \ Solid Fuels	CO ₂	2,397	401	0.00	0.01	0.70

A		B	C	D	E	F	G
IPCC Source Categories		Gas	Base Year Estimate	Current Year Estimate	Trend Assessment	% Contribution to Trend	Cumulative Total of Column F
3.D.a.3	Agricultural Soils \ Direct Soil Emissions \ Urine and Dung Deposited by Grazing Animals	N ₂ O	4,434	3,427	0.00	0.01	0.71
1.B.2.C.2	Fugitives\Venting and Flaring, \ Flaring \Gas	CO ₂	3,601	2,485	0.00	0.01	0.72
1.A.2.F	Other (please specify) \ Construction \ Liquid Fuels	CO ₂	2,838	1,502	0.00	0.01	0.73
1.A.4.B	Residential \ Biomass	CH ₄	2,403	941	0.00	0.01	0.75
1.A.2.B	Non-Ferrous Metals \ Gaseous Fuels	CO ₂	4,170	7,517	0.00	0.01	0.76
1.A.1.B	Petroleum Refining \ Liquid Fuels	CO ₂	4,931	4,314	0.00	0.01	0.77
1.A.4.B	Residential \ Gaseous Fuels	CO ₂	4,646	7,962	0.00	0.01	0.78
1.A.4.C	Agriculture/ Forestry/ Fisheries \ Liquid Fuels	CO ₂	3,406	6,287	0.00	0.01	0.79
1.B.2.C.1.2	Fugitives\ Venting and Flaring\ Venting\ Gas	CH ₄	2,064	858	0.00	0.01	0.80
2.B	Chemicals	CO ₂	603	2,290	0.00	0.01	0.81
1.A.3.D	Domestic Navigation \ Liquid Fuels	CO ₂	2,469	1,802	0.00	0.01	0.81
1.A.2.C	Chemicals \ Gaseous Fuels	CO ₂	1,452	3,261	0.00	0.01	0.82
1.B.2.C.2.2	Fugitives \ Venting and Flaring \ Flaring\ Gas	CH ₄	1,124	110	0.00	0.01	0.83
2.A.1	Cement Industry	CO ₂	3,463	3,294	0.00	0.01	0.84
1.A.1.A	Public Electricity and Heat Production \ Liquid Fuels	CO ₂	2,907	2,631	0.00	0.01	0.84
1.B.2.C.1.2	Fugitives\Venting and Flaring\ Venting\ Gas	CO ₂	1,966	3,640	0.00	0.01	0.85
3.E	Prescribed Burning of Savannas	CH ₄	4,460	6,868	0.00	0.01	0.85
1.B.1.A.2.1	Surface Mining\ Mining Activities	CH ₄	3,351	5,387	0.00	0.01	0.86
2.C.3	Aluminium Production	C ₂ F ₆	813	29	0.00	0.01	0.87
1.A.2.B	Non-Ferrous Metals \ Solid Fuels	CO ₂	4,132	4,406	0.00	0.01	0.87
1.A.2.F	Other (please specify) \ Mineral industry \ Gaseous Fuels	CO ₂	2,972	2,955	0.00	0.00	0.88

A		B	C	D	E	F	G
IPCC Source Categories		Gas	Base Year Estimate	Current Year Estimate	Trend Assessment	% Contribution to Trend	Cumulative Total of Column F
1.B.2.B.1	Fugitive Emissions From Fuels, Oil and Natural Gas, Natural Gas, Exploration	CH ₄	133	1,031	0.00	0.00	0.88
1.A.2.A	Iron and Steel \ Gaseous Fuels	CO ₂	1,393	959	0.00	0.00	0.88
3.B.3	Manure Management \ Swine	CH ₄	1,546	1,192	0.00	0.00	0.89
1.A.2.C	Chemicals \ Solid Fuels	CO ₂	876	344	0.00	0.00	0.89
1.A.3.C	Railways \ Liquid Fuels	CO ₂	1,734	3,001	0.00	0.00	0.90
1.A.2.F	Other (please specify) \ Mineral industry \ Solid Fuels	CO ₂	2,212	2,189	0.00	0.00	0.90
3.D.a.1	Direct Soil Emissions \ Inorganic Fertilisers	N ₂ O	1,332	2,364	0.00	0.00	0.90
2.B	Chemicals	N ₂ O	995	1,921	0.00	0.00	0.91
1.A.2.C	Chemicals \ Liquid Fuels	CO ₂	3,297	4,891	0.00	0.00	0.91
2.F.1	Refrigeration and air-conditioning	HFC-143a	-	596	0.00	0.00	0.91
1.A.4.A	Commercial / Institutional \ Solid Fuels	CO ₂	523	87	0.00	0.00	0.92
1.A.2.E	Food Processing, Beverages and Tobacco \ Solid Fuels	CO ₂	1,214	987	0.00	0.00	0.92
1.A.2.A	Iron and Steel \ Solid Fuels	CO ₂	1,206	994	0.00	0.00	0.92
1.A.2.F	Other (please specify) \ Mining \ Solid Fuels	CO ₂	671	305	0.00	0.00	0.93
1.B.2.C.2.1	Fugitives \ Venting and Flaring \ Flaring \ Oil	CO ₂	-	524	0.00	0.00	0.93
1.A.4.A	Commercial/ Institutional \ Liquid Fuels	CO ₂	1,246	2,130	0.00	0.00	0.93
3.B.1	Manure Management \ Cattle	CH ₄	497	1,146	0.00	0.00	0.94
1.A.3.B	Road Transportation \ Liquid Fuels	CH ₄	556	249	0.00	0.00	0.94
1.A.3.B	Road Transportation \ Liquid Fuels	N ₂ O	663	1,302	0.00	0.00	0.94
1.A.2.B	Non-Ferrous Metals \ Liquid Fuels	CO ₂	2,849	4,127	0.00	0.00	0.94
1.A.4.B	Residential \ Liquid Fuels	CO ₂	1,320	1,295	0.00	0.00	0.95

A		B	C	D	E	F	G
IPCC Source Categories		Gas	Base Year Estimate	Current Year Estimate	Trend Assessment	% Contribution to Trend	Cumulative Total of Column F
2.C.3	Aluminium Production	CO ₂	2,058	3,071	0.00	0.00	0.95
3.D.b.2	Agricultural Soils \ Indirect Soil Emissions \ Nitrogen Leaching and Run-Off	N ₂ O	1,921	2,098	0.00	0.00	0.95

Table A1.6: Key categories for Australia's 2013 inventory – summary excluding LULUCF

A		B	C	D
IPCC Source Categories		Gas	Key Source Category Flag	If Column C is Yes, Criteria for Identification
1.A.1.a	Public Electricity and Heat Production \ Solid Fuels	CO ₂	YES	Level, Trend
1.A.1.a	Public Electricity and Heat Production \ Gaseous Fuels	CO ₂	YES	Level, Trend
1.A.1.a	Public Electricity and Heat Production \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.1.b	Petroleum Refining \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.1.c	Manufacture of Solid Fuels and Other Energy Industries \ Gaseous Fuels	CO ₂	YES	Level, Trend
1.A.1.c	Manufacture of Solid Fuels and Other Energy Industries \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.1.c	Manufacture of Solid Fuels and Other Energy Industries \ Solid Fuels	CO ₂	YES	Trend
1.A.2.a	Iron and Steel \ Gaseous Fuels	CO ₂	YES	Trend
1.A.2.a	Iron and Steel \ Solid Fuels	CO ₂	YES	Trend
1.A.2.b	Non-Ferrous Metals \ Gaseous Fuels	CO ₂	YES	Level, Trend
1.A.2.b	Non-Ferrous Metals \ Solid Fuels	CO ₂	YES	Level, Trend
1.A.2.b	Non-Ferrous Metals \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.2.c	Chemicals \ Liquid Fuels	CO ₂	YES	Trend, Trend
1.A.2.c	Chemicals \ Gaseous Fuels	CO ₂	YES	Level, Trend
1.A.2.c	Chemicals \ Solid Fuels	CO ₂	YES	Trend
1.A.2.e	Food Processing, Beverages and Tobacco \ Gaseous Fuels	CO ₂	YES	Level
1.A.2.e	Food Processing, Beverages and Tobacco \ Solid Fuels	CO ₂	YES	Trend
1.A.2.f	Other (please specify) \ Mining \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.2.f	Other (please specify) \ Mineral industry \ Gaseous Fuels	CO ₂	YES	Level, Trend
1.A.2.f	Other (please specify) \ Mineral industry \ Solid Fuels	CO ₂	YES	Level, Trend
1.A.2.f	Other (please specify) \ Construction \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.2.f	Other (please specify) \ Mining \ Solid Fuels	CO ₂	YES	Trend
1.A.3.a	Domestic Aviation \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.3.b	Road Transportation \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.3.b	Road Transportation \ Liquid Fuels	CH ₄	YES	Trend
1.A.3.b	Road Transportation \ Liquid Fuels	N ₂ O	YES	Level, Trend
1.A.3.c	Railways \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.3.d	Navigation \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.4.a	Commercial/Institutional \ Gaseous Fuels	CO ₂	YES	Level
1.A.4.a	Commercial/Institutional \ Liquid Fuels	CO ₂	YES	Level, Trend

A		B	C	D
IPCC Source Categories		Gas	Key Source Category Flag	If Column C is Yes, Criteria for Identification
1.A.4.a	Commercial/Institutional \ Solid Fuels	CO ₂	YES	Trend
1.A.4.b	Residential \ Gaseous Fuels	CO ₂	YES	Level, Trend
1.A.4.b	Residential \ Biomass	CH ₄	YES	Trend
1.A.4.b	Residential \ Liquid Fuels	CO ₂	YES	Level, Trend
1.A.4.c	Agriculture/Forestry/Fisheries \ Liquid Fuels	CO ₂	YES	Level, Trend
1.B.1.A.1	Fugitives \ Solid fuels \ Underground Mines	CH ₄	YES	Level, Trend
1.B.1.A.2.1	Surface Mining \ Mining Activities	CH ₄	YES	Level, Trend
1.B.2.B.1	Fugitive Emissions From Fuels, Oil and Natural Gas, Natural Gas, Exploration	CH ₄	YES	Trend
1.B.2.B.5	Fugitive Emissions From Fuels, Oil and Natural Gas, Natural Gas, Distribution	CH ₄	YES	Level, Trend
1.B.2.C.1.2	Fugitives \ Venting and Flaring \ Venting \ Gas	CO ₂	YES	Trend
1.B.2.C.1.2	Fugitives \ Venting and Flaring \ Venting \ Gas	CH ₄	YES	Level, Trend
1.B.2.C.2.1	Fugitives \ Venting and Flaring \ Flaring \ Oil	CO ₂	YES	Trend
1.B.2.C.2.2	Fugitives \ Venting and Flaring \ Flaring \ Gas	CO ₂	YES	Level, Trend
1.B.2.C.2.2	Fugitives \ Venting and Flaring \ Flaring \ Gas	CH ₄	YES	Trend
2.A.1	Cement Production	CO ₂	YES	Level, Trend
2.A.2	Lime Production	CO ₂	YES	Level
2.A.3	Glass Production	CO ₂	YES	Level
2.B	Chemical	CO ₂	YES	Level, Trend
2.B	Chemical	N ₂ O	YES	Level, Trend
2.C.1.d	Iron and Steel \ Coke	CO ₂	YES	Level, Trend
2.C.3	Aluminium Production	CO ₂	YES	Level, Trend
2.C.3	Aluminium Production	CF ₄	YES	Trend
2.C.3	Aluminium Production	C ₂ F ₆	YES	Trend
2.F.1	Refrigeration and Air Conditioning Equipment	HFC	YES	Level, Trend
2.F.1	Refrigeration and Air Conditioning Equipment	HFC-134 _a	YES	Level, Trend
2.F.1	Refrigeration and Air Conditioning Equipment	HFC-125	YES	Level, Trend
2.F.1	Refrigeration and Air Conditioning Equipment	HFC-143 _a	YES	Trend
3.A.1	Enteric Fermentation \ Cattle	CH ₄	YES	Level, Trend
3.A.2	Enteric Fermentation \ Sheep	CH ₄	YES	Level, Trend
3.B.1	Manure Management \ Cattle	CH ₄	YES	Trend
3.B.3	Manure Management \ Swine	CH ₄	YES	Level, Trend
3.D.a.1	Agricultural Soils \ Direct Soil Emissions \ Inorganic Fertilisers	N ₂ O	YES	Level, Trend
3.D.a.3	Agricultural Soils \ Direct Soil Emissions \ Urine and Dung Deposited by Grazing Animals	N ₂ O	YES	Level, Trend
3.D.a.4	Agricultural Soil \ Direct Soil Emissions \ Crop Residue	N ₂ O	YES	Level

A		B	C	D
IPCC Source Categories		Gas	Key Source Category Flag	If Column C is Yes, Criteria for Identification
3.D.b.2	Agricultural Soils \ Indirect Soil Emissions \ Nitrogen Leaching and Run-Off	N ₂ O	YES	Level, Trend
3.E	Prescribed Burning of Savannas	CH ₄	YES	Level, Trend
3.H	Urea Application	CO ₂	YES	Level
5.A.1	Managed Waste Disposal on Land	N ₂ O	YES	Level, Trend

Table A1.7: Summary overview for key categories for Land use, Land-use Change and Forestry activities under the Kyoto Protocol – 2013

Key Categories of Emissions and Removals	Gas	Criteria used for Key Category Identification			Comments
		Associated category in UNFCCC inventory is key	Category contribution is greater than the smallest category considered key in the UNFCCC inventory (including LULUCF)	Other	
Deforestation	CO ₂	forest land converted to grassland	Yes	NA	
Forest management	CO ₂	forest land remaining forest land	Yes	NA	Australia has applied the narrow approach to forest management. As a result the forest land remaining forest land classification does not directly correspond to the forest management activity.
Deforestation	CO ₂	forest land converted to cropland	Yes	NA	
Afforestation/Reforestation	CO ₂	grassland converted to forest land	Yes	NA	
Grazing land management	CO ₂	grassland remaining grassland, land converted to grassland (conversion prior to 1990)	Yes	NA	
Cropland management	CO ₂	cropland remaining cropland, land converted to cropland (conversion prior to 1990)	Yes	NA	

ANNEX 2: Uncertainty Analysis

Uncertainty is inherent within any kind of estimation – be it an estimate of the national greenhouse gas emissions, or the national gross domestic product. While it is in some cases possible to continuously monitor emissions, it is not usually practical or economic to do so. This leads to estimations based on samples or studies being used which carry a degree of additional uncertainty attached to them. Uncertainty also arises from the limitations of the measuring instruments, and over the complexities of the modelling of key relationships between observed variables and emissions.

The purpose of estimating the uncertainty attached to emissions estimates is principally to provide information on where inventory resources should be allocated to maximise the future improvements to inventory quality.

Assessing uncertainty is, itself, a difficult exercise, especially in the absence of quantitative data. Australia has conducted an uncertainty analysis for the individual sectors in line with the IPCC 2006 *Guidelines for National Greenhouse Gas Inventories*. Monte Carlo and Latin Hypercube approaches were used to estimate emission uncertainty in some sectors, which is equivalent to the IPCC tier 2 methodology.

The estimates have been mainly prepared by the judgement of the sectoral expert consultants. However, the estimates of uncertainty for the Australian inventory have been reviewed in 2005 by independent experts under protocols developed by the Australian CSIRO Atmospheric Research Division. The CSIRO report confirmed, with one or two exceptions, the quantitative judgements made in relation to uncertainty of inventory estimates and provide a strong basis for confidence in the assessments reported in this chapter.

The uncertainties for individual sectors are reported in more detail below. The estimated uncertainties tend to be low for carbon dioxide from energy consumption as well as from some industrial process emissions. Uncertainty surrounding estimates from these sources are typically as low as ± 4 –5%. Uncertainty surrounding estimates of emissions are higher for agriculture, land use change and forestry, reflecting inherently high uncertainty due to the very nature of the processes involved (e.g. biological processes). A medium band of uncertainty applies to estimates from fugitive emissions, most industrial processes and non-CO₂ gases in the energy sector. The ranges presented are broadly consistent with the typical uncertainty ranges expected for each sector, as identified in IPCC 2006.

The estimates of uncertainty surrounding the emissions estimates for individual sectors may be combined to present an estimate of the overall uncertainty for the inventory as a whole. Following the recommendations of IPCC 2006, the emission estimates across the energy sector have been aggregated because of the hidden dependencies that exist between sectoral activity levels as a result of the constraint of overall consumption and since aggregate fuel consumption is more accurately known than the consumption in individual sectors. The results of the application of the IPCC tier 1 approach to estimating the uncertainty of the inventory as a whole, which identifies separately estimates of uncertainty for both activity and emission factors where available, and which does not account for correlations between variables (unlike some of the sectoral analyses), are presented in Table A2.1.

As indicated in IPCC 2006, the tier 1 approach is valid as long as a number of restrictive assumptions are met. An alternative, more flexible approach, which relies on Monte Carlo analysis and a more detailed specification of the sources of uncertainty, is currently under consideration for development by the DE for use in future national inventory reports. This analysis would be equivalent to the IPCC tier 2 approach and would take into consideration a number of refinements proposed by the CSIRO independent review.

The tier 1 results presented in Table A.2.1 show the estimated uncertainty surrounding the aggregate inventory estimate for 2013 to be $\pm 4.8\%$. The reported estimated uncertainty for the trend in emissions is $\pm 5.1\%$. This estimate has been calculated on the assumption that the total uncertainty for parts of agriculture, land use, land use change and forestry, and the waste sectors are uncorrelated through time.

Much of the uncertainty for the UNFCCC inventory derives from the LULUCF sector. The uncertainty for the aggregate inventory excluding LULUCF is estimated at $\pm 4.8\%$ and the uncertainty in the trend is estimated $\pm 5.1\%$ (Table A2.2).

Gas	Base year emissions	1990 Gg CO ₂ e	2013 Gg CO ₂ e	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Uncertainty in total inventory	Type A Sensitivity	Type B Sensitivity	Uncertainty in trend of EF	Uncertainty in trend of activity data	Uncertainty in trend of total emissions	Footnote ref. no.
B	C	D	E	F	G	H	I	J	K	L	M	N	
CO ₂	131,997	167,564	0.8	0.8	1.06	0.329	0.060	0.318	0.045	0.3	0.3	1.2	
CH ₄	29	38	2	5	5.39	0.000	0.000	0.000	0.000	0.000	0.0	1	
N ₂ O	378	810	2	20	20.10	0.030	0.001	0.002	0.016	0.0	0.0	1	
CO ₂	86,331	133,436	2	3	3.61	0.887	0.084	0.254	0.253	0.7	0.8	1	
CH ₄	734	476	2	40	40.05	0.035	-0.001	0.001	-0.021	0.0	0.0	1	
N ₂ O	1,119	2,130	2	60	60.03	0.236	0.002	0.004	0.111	0.0	0.1	1	
CO ₂	33,348	66,392	2	3	3.61	0.441	0.061	0.126	0.182	0.4	0.4	1	
CH ₄	22	243	2	5	5.39	0.002	0.000	0.000	0.002	0.0	0.0	1	
N ₂ O	241	295	2	20	20.10	0.011	0.000	0.001	0.002	0.0	0.0	1	
CH ₄	2,427	1,046	0	20	20.00	0.039	-0.003	0.002	-0.055	0.0	0.1	8	
N ₂ O	225	207	0	20	20.00	0.008	0.000	0.000	-0.001	0.0	0.0	8	
CO ₂	1,184	1,888	5	20	20.62	0.072	0.001	0.004	0.025	0.0	0.0	1,3	
CH ₄	20,991	24,267	5	20	20.62	0.923	0.005	0.046	0.100	0.3	0.3	1,3	
Gas - Oil	393	219	5	5	7.07	0.003	0.000	0.000	-0.002	0.0	0.0	1,4	
CO ₂	21	74	10	3	10.44	0.001	0.000	0.000	0.000	0.0	0.0	1,4	
Gas -	5,568	6,649	5	5	7.07	0.087	0.002	0.013	0.009	0.1	0.1	1,4	
CO ₂	77	86	5	5	7.07	0.001	0.000	0.000	0.000	0.0	0.0	1,4	
Gas - Oil	4,594	2,952	10	3	10.44	0.057	-0.003	0.006	-0.010	0.1	0.1	1,4	
CH ₄													
Gas -													

Reporting table for uncertainty including LULUCF

A

A	IPCC Source category
	1.A. Solid fossil fuels
	1.A. Liquid fossil fuels
	1.A Gaseous fossil fuels
	1.A. Biomass fuels
	1.B.1.a Coal Mining and Handling
	1.B.1.a Coal Mining and Handling
	1.B.2.a Oil and Natural Gas
	1.B.2.b Oil and Natural Gas
	Natural Gas
	Venting and Flaring
	1.B.2.a Oil and Natural Gas
	1.B.2.b Oil and Natural Gas
	Natural Gas

A	B	C	D	E	F	G	H	I	J	K	L	M	Q
IPCC Source category	Gas	Base year emissions Gg CO ₂ e	Year t emissions Gg CO ₂ e	Activity data uncert'y	Emission factor uncert'y	Combined uncert'y	Uncert'y in total inventory	Type A Sensit'y	Type B Sensit'y	Uncert'y in trend of EF	Uncert'y in trend of activity data	Uncert'y in trend of total emissions	footnote ref no.
		1990 Gg CO ₂ e	2013 Gg CO ₂ e	%	%	%	%	%	%	%	%	%	
1.B.2 Oil and Natural Gas - Venting and Flaring	CH ₄	3,189	1,944	5	5	7.07	0.025	-0.003	0.004	-0.013	0.0	0.0	1,4
1.B.2.a Oil and Natural Gas - Oil	N ₂ O	3	4	2	20	20.10	0.000	0.000	0.000	0.000	0.0	0.0	1
1.B.2.b Oil and Natural Gas - Natural Gas	N ₂ O	0	0	2	20	20.10	0.000	0.000	0.000	0.000	0.0	0.000	1
1.B.2 Oil and Natural Gas - Venting and Flaring	N ₂ O	31	17	2	20	20.10	0.001	0.000	0.000	-0.001	0.0	0.001	1
2.A.1 Cement Production	CO ₂	3,463	3,294	2.5	2.5	3.54	0.021	-0.001	0.006	-0.001	0.0	0.022	5
2.A.2 Lime Production	CO ₂	775	1,257	2.5	2.5	3.54	0.008	0.001	0.002	0.002	0.0	0.009	5
2.A.3 Other Process Uses of Carbonates	CO ₂	1,252	1,549	4	2.5	4.72	0.013	0.000	0.003	0.001	0.0	0.017	5
2.B Chemicals	CO ₂	1,114	3,243	5	5	7.07	0.042	0.004	0.006	0.020	0.0	0.048	5
	CH ₄	11	14	5	5	7.07	0.000	0.000	0.000	0.000	0.0	0.000	5
	N ₂ O	995	2,660	5	5	7.07	0.035	0.003	0.005	0.016	0.0	0.039	6
2.C.1 Iron and Steel Production	CO ₂	9,203	6,679	2.5	5	5.59	0.069	-0.005	0.013	-0.027	0.0	0.052	5
	CH ₄	71	68	2	5	5.39	0.001	0.000	0.000	0.000	0.0	0.000	5
	N ₂ O	18	18	2	20	20.10	0.001	0.000	0.000	0.000	0.0	0.000	6
2.C.3 Aluminium Production	CO ₂	2,058	3,071	2.5	2.5	3.54	0.020	0.002	0.006	0.005	0.0	0.021	5
	PFCs	3,950	259	0	27	27.00	0.013	-0.007	0.000	-0.196	0.0	0.196	5
2.C.2 Ferroalloys Production	CO ₂	323	433	2.5	5	5.59	0.004	0.000	0.001	0.001	0.0	0.003	5
2.C.7 Other	CO ₂	220	273	2.5	5	5.59	0.003	0.000	0.001	0.000	0.0	0.002	5
2.H.2 Food and Beverages Industry	CO ₂	83	255	0	2.5	2.50	0.001	0.000	0.000	0.001	0.0	0.001	6

A	B	C	D	E	F	G	H	I	J	K	L	M	Q
IPCC Source category	Gas	Base year emissions	Year t emissions	Activity data	Emission factor	Combined uncertainty	Uncertainty in total inventory	Type A Sensitivity	Type B Sensitivity	Uncertainty in trend of EF	Uncertainty in trend of activity data	Uncertainty in trend of total emissions	footnote ref no.
		1990 Gg CO ₂ e	2013 Gg CO ₂ e	%	%	%	%	%	%	%	%	%	
2.F Product Uses as Substitutes for Ozone Depleting Substances	HFCs	0	7,641	0	27	27.00	0.380	0.015	0.015	0.392	0.0	0.392	5
	SF ₆	221	149	0	27	27.00	0.007	0.000	0.000	-0.004	0.0	0.004	5
	CH ₄	66,976	60,279	10	20	22.36	2.486	-0.017	0.115	-0.166	1.6	1.629	6
	CH ₄	2,090	2,738	22.4	30	37.42	0.189	0.001	0.005	0.025	0.2	0.166	6
3.B Manure Management	N ₂ O	405	925	22.4	50	54.77	0.093	0.001	0.002	0.048	0.1	0.074	6
	CH ₄	562	223	5.0	10	11.18	0.005	-0.001	0.000	-0.007	0.0	0.007	7
	N ₂ O	11,838	12,952	25.0	50	55.90	1.335	0.001	0.025	0.071	0.9	0.873	7
3.D Agricultural Soils	CH ₄	4,460	6,514	42.5	20	46.95	0.564	0.004	0.012	0.073	0.7	0.747	7
3.E Prescribed burning of Savannahs	N ₂ O	1,205	2,032	43.6	20	48.00	0.180	0.002	0.004	0.030	0.2	0.240	7
	CH ₄	292	228	32.4	20	38.08	0.016	0.000	0.000	-0.003	0.0	0.020	7
3.F Agricultural Residue Burning	N ₂ O	205	156	32.4	20	38.08	0.011	0.000	0.000	-0.002	0.0	0.014	7
	CO ₂	170	761	20	50	38.08	0.053	0.001	0.001	0.056	0.0	0.069	8
3.G Liming	CO ₂	367	1,278	10	50	38.08	0.090	0.002	0.002	0.086	0.0	0.092	9
3.H Urea application	CO ₂	-29,780	-25,806	15	30	38.08	-1.812	0.009	-0.049	0.279	-1.0	1.077	
	CH ₄	614	424	15	30	38.08	0.030	0.000	0.001	-0.012	0.0	0.021	
	N ₂ O	217	110	15	30	38.08	0.008	0.000	0.000	-0.007	0.0	0.008	
4.A.1 Forest Land remaining Forest Land	CO ₂	1,513	-12,932	11	11.5	38.08	-0.908	-0.028	-0.025	-0.317	-0.4	0.496	
4.A.2 Land converted to Forest Land	CO ₂	-69	-2,216	25	20	38.08	-0.156	-0.004	-0.004	-0.082	-0.1	0.170	

A	B	C	D	E	F	G	H	I	J	K	L	M	Q
IPCC Source category	Gas	Base year emissions Gg CO ₂ e	Year t emissions Gg CO ₂ e	Activity data uncertainty %	Emission factor uncertainty %	Combined uncertainty %	Uncertainty in total inventory %	Type A Sensitivity %	Type B Sensitivity %	Uncertainty in trend of EF %	Uncertainty in trend of activity data %	Uncertainty in trend of total emissions %	footnote ref no.
4.B.2.1 Forest Land converted to Cropland	CO ₂	9,178	3,534	11	25	38.08	0.248	-0.011	0.007	-0.281	0.1	0.300	
	CH ₄	326	269	11	25	38.08	0.019	0.000	0.001	-0.003	0.0	0.009	
	N ₂ O	90	78	11	25	38.08	0.005	0.000	0.000	-0.001	0.0	0.002	
4.C.1 Grassland remaining Grassland	CO ₂	-3,952	-2,685	25	20	38.08	-0.189	0.003	-0.005	0.053	-0.2	0.188	
4.C.2.1 Forest Land converted to Grasslands	CO ₂	121,099	36,521	11	25	38.08	2.565	-0.167	0.069	-4.184	1.1	4.321	
	CH ₄	4,009	2,723	11	25	38.08	0.191	-0.003	0.005	-0.067	0.1	0.105	
	N ₂ O	1,154	864	11	25	38.08	0.061	-0.001	0.002	-0.015	0.0	0.030	
5.A Solid Waste Disposal	CH ₄	16,269	12,289	0	3.25	38.08	0.863	-0.009	0.023	-0.028	0.0	0.028	5
5.B Wastewater Treatment and Discharge	CH ₄	4,127	2,851	0	50	50.00	0.263	-0.003	0.005	-0.133	0.0	0.133	5
	N ₂ O	303	365	0	50	50.00	0.034	0.000	0.001	0.005	0.0	0.005	5
5.C Incineration and Open Burning of Waste	CO ₂	73	30	0	40	40.00	0.002	0.000	0.000	-0.003	0.0	0.003	5
	N ₂ O	11		0	40	40.00	0.000	0.000	0.000	-0.001	0.0	0.001	6
5.D Other	CH ₄	0	0	0	100	100.00	0.000	0.000	0.000	0.000	0.0	0.000	
	N ₂ O	0	9	0	100	100.00	0.002	0.000	0.000	0.002	0.0	0.002	
Total Emissions		526,202	542,270										
Total Uncertainties							4.8					5.1	

1. Energy Strategies; 2. NGER; 3. Dr David Williams, CSIRO; 4. Australian Petroleum Production & Exploration Association; 5. Burnbank Consulting; 6. Dr Mark Howden, CSIRO; 7. Dr Carl Meyer, CSIRO;

8. Dr Gary Richards, Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education.

Table A2.2: General reporting table for uncertainty excluding LULUCF

A	B	C	D	E	F	G	H	I	J	K	L	M	Q
IPCC Source category	Gas	Base year emissions	Year t emissions	Activity data	Emission factor	Combined uncertainty	Uncertainty in total inventory	Type A Sensitivity	Type B Sensitivity	Uncertainty in trend of EF	Uncertainty in trend of activity data	Uncertainty in trend of total emissions	footnote ref no.
		1990 Gg CO ₂ e	2013 Gg CO ₂ e	%	%	%	%	%	%	%	%	%	
1.A. Solid fossil fuels	CO ₂	131,997	167,564	0.8	0.8	1.06	0.329	0.060	0.318	0.045	0.3	0.3	1,2
	CH ₄	29	38	2.0	5.0	5.39	0.000	0.000	0.000	0.000	0.0	0.0	1
	N ₂ O	378	810	2.0	20.0	20.10	0.030	0.001	0.002	0.016	0.0	0.0	1
1.A. Liquid fossil fuels	CO ₂	86,331	133,436	2.0	3.0	3.61	0.887	0.084	0.254	0.253	0.7	0.8	1
	CH ₄	734	476	2.0	40.0	40.05	0.035	-0.001	0.001	-0.021	0.0	0.0	1
	N ₂ O	1,119	2,130	2.0	60.0	60.03	0.236	0.002	0.004	0.111	0.0	0.1	1
1.A. Gaseous fossil fuels	CO ₂	33,348	66,392	2.0	3.0	3.61	0.441	0.061	0.126	0.182	0.4	0.4	1
	CH ₄	22	243	2.0	5.0	5.39	0.002	0.000	0.000	0.002	0.0	0.0	1
	N ₂ O	241	295	2.0	20.0	20.10	0.011	0.000	0.001	0.002	0.0	0.0	1
1.A. Biomass fuels	CH ₄	2,427	1,046	0.0	20.0	20.00	0.039	-0.003	0.002	-0.055	0.0	0.1	8
	N ₂ O	225	207	0.0	20.0	20.00	0.008	0.000	0.000	-0.001	0.0	0.0	8
	CO ₂	1,184	1,888	5.0	20.0	20.62	0.072	0.001	0.004	0.025	0.0	0.0	1,3
1.B.1.a Coal Mining and Handling	CH ₄	20,991	24,267	5.0	20.0	20.62	0.923	0.005	0.046	0.100	0.3	0.3	1,3
1.B.2.a Oil and Natural Gas – Oil	CO ₂	393	219	5.0	5.0	7.07	0.003	0.000	0.000	-0.002	0.0	0.0	1,4
1.B.2.b Oil and Natural Gas – Natural Gas	CO ₂	21	74	10.0	3.0	10.44	0.001	0.000	0.000	0.000	0.0	0.0	1,4
1.B.2 Oil and Natural Gas – Venting and Flaring	CO ₂	5,568	6,649	5.0	5.0	7.07	0.087	0.002	0.013	0.009	0.1	0.1	1,4
1.B.2.a Oil and Natural Gas – Oil	CH ₄	77	86	5.0	5.0	7.07	0.001	0.000	0.000	0.000	0.0	0.0	1,4
1.B.2.b Oil and Natural Gas – Natural Gas	CH ₄	4,594	2,952	10.0	3.0	10.44	0.057	-0.003	0.006	-0.010	0.1	0.1	1,4
1.B.2 Oil and Natural Gas – Venting and Flaring	CH ₄	3,189	1,944	5.0	5.0	7.07	0.025	-0.003	0.004	-0.013	0.0	0.0	1,4

A	B	C	D	E	F	G	H	I	J	K	L	M	Q
IPCC Source category	Gas	Base year emissions		Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Uncertainty in total inventory	Type A Sensitivity	Type B Sensitivity	Uncertainty in trend of EF	Uncertainty in trend of activity data	Uncertainty in trend of total emissions	footnote ref no.
		1990 Gg CO ₂ e	2013 Gg CO ₂ e										
1.B.2.a Oil and Natural Gas – Oil	N ₂ O	3	4	2.0	20.0	20.10	0.000	0.000	0.000	0.000	0.0	0.0	1
1.B.2.b Oil and Natural Gas – Natural Gas	N ₂ O	0	0	2.0	20.0	20.10	0.000	0.000	0.000	0.000	0.0	0.0	1
1.B.2 Oil and Natural Gas – Venting and Flaring	N ₂ O	31	17	2.0	20.0	20.10	0.001	0.000	0.000	-0.001	0.0	0.0	1
2.A.1 Cement Production	CO ₂	3,463	3,294	2.5	2.5	3.54	0.021	-0.001	0.006	-0.001	0.0	0.0	5
2.A.2 Lime Production	CO ₂	775	1,257	2.5	2.5	3.54	0.008	0.001	0.002	0.002	0.0	0.0	5
2.A.3 Other Process Uses of Carbonates	CO ₂	1,252	1,549	4.0	2.5	4.72	0.013	0.000	0.003	0.001	0.0	0.0	5
2.B Chemicals	CO ₂	1,114	3,243	5.0	5.0	7.07	0.042	0.004	0.006	0.020	0.0	0.0	5
	CH ₄	11	14	5.0	5.0	7.07	0.000	0.000	0.000	0.000	0.0	0.0	5
2.C.1 Iron and Steel Production	N ₂ O	995	2,660	5.0	5.0	7.07	0.035	0.003	0.005	0.016	0.0	0.0	6
	CO ₂	9,203	6,679	2.5	5.0	5.59	0.069	-0.005	0.013	-0.027	0.0	0.1	5
	CH ₄	71	68	2.0	5.0	5.39	0.001	0.000	0.000	0.000	0.0	0.0	5
	N ₂ O	18	18	2.0	20.0	20.10	0.001	0.000	0.000	0.000	0.0	0.0	6
2.C.3 Aluminium Production	CO ₂	2,058	3,071	2.5	2.5	3.54	0.020	0.002	0.006	0.005	0.0	0.0	5
	PFCs	3,950	259	0.0	27.0	27.00	0.013	-0.007	0.000	-0.196	0.0	0.2	5
2.C.2 Ferroalloys Production	CO ₂	323	433	2.5	5.0	5.59	0.004	0.000	0.001	0.001	0.0	0.0	5
	CO ₂	220	273	2.5	5.0	5.59	0.003	0.000	0.001	0.000	0.0	0.0	5
2.H.2 Food and Beverages Industry	CO ₂	83	255	0.0	2.5	2.50	0.001	0.000	0.000	0.001	0.0	0.0	6
2.F Product Uses as Substitutes for Ozone Depleting Substances	HFCs	0	7,641	0.0	27.0	27.00	0.380	0.015	0.015	0.392	0.0	0.4	5
3.A Enteric Fermentation	CH ₄	66,976	60,279	10.0	20.0	22.36	2.486	-0.017	0.115	-0.166	1.6	1.6	6
3.B Manure Management	CH ₄	2,090	2,738	22.4	30.0	37.42	0.189	0.001	0.005	0.025	0.2	0.2	6

A	B	C	D	E	F	G	H	I	J	K	L	M	Q
IPCC Source category	Gas	Base year emissions	Year t emissions	Activity data	Emission factor	Combined uncertainty	Uncert'y in total inventory	Type A Sensit'y	Type B Sensit'y	Uncert'y in trend of EF	Uncert'y in trend of activity data	Uncert'y in trend of total emissions	footnote ref no.
		1990 Gg CO ₂ e	2013 Gg CO ₂ e	%	%	%	%	%	%	%	%	%	
3.A Enteric Fermentation	CH ₄	66,976	60,279	10.0	20.0	22.36	2.486	-0.017	0.115	-0.166	1.6	1.6	6
3.B Manure Management	CH ₄	2,090	2,738	22.4	30.0	37.42	0.189	0.001	0.005	0.025	0.2	0.2	6
	N ₂ O	405	925	22.4	50.0	54.77	0.093	0.001	0.002	0.048	0.1	0.1	6
3.C Rice Cultivation	CH ₄	562	223	5.0	10.0	11.18	0.005	-0.001	0.000	-0.007	0.0	0.0	7
3.D Agricultural Soils	N ₂ O	11,838	12,952	25.0	50.0	55.90	1.335	0.001	0.025	0.071	0.9	0.9	7
3.E Prescribed burning of Savannahs	CH ₄	4,460	6,514	42.5	20.0	46.95	0.564	0.004	0.012	0.073	0.7	0.7	7
	N ₂ O	1,205	2,032	43.6	20.0	48.00	0.180	0.002	0.004	0.030	0.2	0.2	7
3.F Agricultural Residue Burning	CH ₄	292	228	32.4	20.0	38.08	0.016	0.000	0.000	-0.003	0.0	0.0	7
	N ₂ O	205	156	32.4	20.0	38.08	0.011	0.000	0.000	-0.002	0.0	0.0	7
3.G Liming	CO ₂	16,269	12,289	20.0	50.0	38.08	0.053	0.001	0.001	0.056	0.0	0.1	8
3.H Urea application	CO ₂	4,127	2,851	10.0	50.0	38.08	0.090	0.002	0.002	0.086	0.0	0.1	9
5.A Solid Waste Disposal	CH ₄	16,269	12,289	0.0	3.3	38.08	0.863	-0.009	0.023	-0.028	0.0	0.0	5
5.A Solid Waste Disposal	CH ₄	4,127	2,851	0.0	50.0	50.00	0.263	-0.003	0.005	-0.133	0.0	0.1	5
5.B Wastewater Treatment and Discharge	CH ₄	303	365	0.0	50.0	50.00	0.263	-0.003	0.005	-0.133	0.0	0.1	5
	N ₂ O	73	30	0.0	50.0	50.00	0.034	0.000	0.001	0.005	0.0	0.0	5
5.C Incineration and Open Burning of Waste	CO ₂	11	0	0.0	40.0	40.00	0.002	0.000	0.000	-0.003	0.0	0.0	5
	N ₂ O	0	0	0.0	40.0	40.00	0.000	0.000	0.000	-0.001	0.0	0.0	6
5.D Other	CH ₄	0	9	0.0	100.0	100.00	0.000	0.000	0.000	0.000	0.0	0.0	0
	N ₂ O	0	0	0.0	100.0	100.00	0.002	0.000	0.000	0.002	0.0	0.0	
Total Emissions		514,935	621,346										
Total Uncertainties							4.8					5.1	

1. Energy Strategies; 2. NGER; 3. Dr David Williams, CSIRO; 4. Australian Petroleum Production & Exploration Association; 5. Burnbank Consulting; 6. Dr Mark Howden, CSIRO; 7. Dr Carl Meyer, CSIRO; 8. Dr Gary Richards, Department of Climate Change and Energy Efficiency.

A2.1 Energy

A2.1.1 Stationary Energy

Uncertainty analyses were conducted for emissions from three sectors: 1.A.1.a. *Electricity*, 1.A.1.b. *Petroleum refining* and 1.A.1.c. *Manufacture of solid fuels and other energy industries* (Table A2.3). The overall uncertainty in estimated emissions from *electricity generation* was $\pm 1\%$. The highest uncertainty was for N_2O emissions, with an associated uncertainty of up to $\pm 16\%$. However, as emissions of N_2O (and CH_4) account for only a small fraction, 0.4%, of the subsector's total emissions, there is a negligible impact on overall uncertainty for this sector.

Australia has investigated the use of NGER uncertainty data in the national inventory uncertainty estimates. Uncertainty data is currently reported by companies under NGER at the corporation level. Therefore for many sectors it is difficult to identify the uncertainty associated with individual sources as company's emissions result from many sources. The sector where NGER uncertainty data is most easily applied is in the electricity generation sector. The emission profile for corporations in this sector are dominated by emissions associated with electricity generation and it is possible to apply the NGER data directly.

Under NGER CO_2 emissions from the combustion of coal or gas for electricity generation must be estimated using facility specific measurements. The use of facility specific measurements based on sampling and analysis of fuels results in relatively low uncertainty estimates as published in Table A2.3.

The electricity uncertainty estimates have been applied in Tables A2.1 and A2.2 to sector 1.A. Solid fossil fuels where the electricity sector is the dominant source. Uncertainty has been equally split between activity data and emission factor uncertainty as data on the composition of total uncertainty is not available under NGER. Australia will review uncertainty estimates reported under NGER and the incorporation of this data into the national uncertainty estimates further in the next annual inventory submission.

Table A2.3: Quantified uncertainty values for key stationary energy subcategories

Greenhouse gas source and sink category	Uncertainty (%) ^(a)			
	CO_2	CH_4	N_2O	Total $\text{CO}_2\text{-e}$
1. ENERGY				
A Fuel combustion activities				
1.A.1.a Electricity	± 1	± 9	± 15	± 1
Black coal	± 2	± 9	± 15	± 2
Brown coal	± 1	± 9	± 15	± 1
Petroleum	± 4	± 9	± 7	± 4
Natural gas	± 2	± 9	± 16	± 2
Biomass	NA	± 9	± 4	± 4
Biogas	NA	± 9	± 16	± 4
1.A.1.b Petroleum refining	± 4	± 9	± 12	± 4
Petroleum	± 4	± 9	± 12	± 4
Gas	± 4	± 9	± 12	± 4
1.A.1.c Manufacture of solid fuels and other energy industries	± 4	± 9	± 12	± 4
Coal	± 4	± 9	± 12	± 4
Petroleum	± 4	± 9	± 12	± 4
Gas	± 4	± 9	± 12	± 4

(a) Uncertainty reported at 95% confidence limits estimated using Latin Hypercube (a type of Monte Carlo) analysis and preliminary

estimates for electricity incorporating NGER uncertainty estimates.

Overall uncertainty associated with emissions estimates from both 1.A.1.b. *Petroleum refining* and 1.A.1.c. *Manufacture of solid fuels and other energy industries* sectors was $\pm 4\%$. Again, the uncertainty associated with emissions of N_2O and CH_4 has negligible impact on overall uncertainty. An uncertainty analysis on minor, mobile source categories of the *stationary energy* sector gave uncertainty values ranging from $\pm 16.4\%$ to $\pm 24.5\%$ for CO_2 , from $\pm 25.4\%$ to $\pm 63.9\%$ for CH_4 , and $\pm 44.7\%$ to $\pm 64.2\%$ for N_2O .

Table A2.4: Quantified uncertainty values for mobile source categories

Greenhouse gas source and sink category	Uncertainty (%) ^(a)		
	CO_2	CH_4	N_2O
1.A.4. Other sectors			
b. Residential			
Lawn mowers	± 24.5	± 45.2	± 46.3
1.A.5. Other			
b. Mobile	± 16.4	± 25.4	± 44.7
Military transport – land	± 18.5	± 32.9	± 54.6
Military transport – water	± 24.4	± 63.9	± 62.7
Military transport – aviation	± 24.0	± 47.2	± 64.2

(a) Uncertainty reported at 95% confidence limits estimated using Monte Carlo analysis.

A2.1.2 Transport

Monte Carlo analyses were conducted for all subsectors and fuel types. The uncertainty distributions for emission factors and activity data were developed on the basis of expert judgment.

The total estimated uncertainties in the *transport* subsector were $\pm 4\%$ for CO_2 , $\pm 24\%$ for CH_4 , and $\pm 42\%$ for N_2O . Uncertainties in the emissions from individual source categories ranged from $\pm 1\%$ to $\pm 24\%$ for CO_2 , $\pm 23\%$ to $\pm 59\%$ for CH_4 , and $\pm 32\%$ to $\pm 63\%$ for N_2O . The largest source of uncertainty is in the emission factors.

The estimates also reflect the relatively higher uncertainty attached to the emission estimates for particular vehicle types, which are drawn from ABS data and its survey of motor vehicle use, than for the sector as a whole. This outcome reflects the dependency between activity variables; and because overall transport fuel consumption is more accurately known than the individual segments.

Table A2.5: Emissions and quantified uncertainty values for key transport subcategories

Greenhouse gas source and sink category	Uncertainty (%) ^(a)		
	CO ₂	CH ₄	N ₂ O
1.A.3. Transport	±4	±24	±42
a. Civil aviation	±9	±52	±52
b. Road transport	±4	±25	±42
i. Passenger cars	±6	±31	±44
ii. Light trucks	±7	±38	±41
iii. Medium trucks	±9	±41	±60
iv. Heavy trucks	±10	±44	±61
v. Buses	±8	±36	±53
vi. Motorcycles	±10	±43	±61
c. Railways	±5	±39	±39
d. Navigation	±8	±59	±32
e. Other transportation	±24	±46	±63
International bunkers			
Aviation	±10	±58	±59
Marine	±4	±47	±52

(a) Uncertainty reported at 95% confidence limits.

A2.1.3 Fugitives

The overall uncertainty for *fugitive* emissions was estimated to be ±11% (Table A2.6). The estimated uncertainty for *solid fuels* CH₄ was ±19%. Uncertainties in oil and natural gas emissions were estimated to be ±4% for CO₂, ±5% for CH₄ and ±4% for N₂O.

Table A2.6: Quantified uncertainty values for key fugitive emissions subcategories

Greenhouse gas source and sink category	Uncertainty (%) ^(a)			
	CO ₂	CH ₄	N ₂ O	CO ₂ -e
1. ENERGY				
B. Fugitive emissions	±4	±14	±4	±11
1.B.1. Solid fuels	NE	±19	NE	±19
1B1ai Underground mines	NE	±21	NE	±21
Underground activities	NE	±21	NE	±21
Post mining	NE	±17	NE	±17
1.B.1.a.i.i. Surface mining	NE	±17	NE	±17
1.B.2. Oil and natural gas	±4	±5	±4	±4
1.B.2.a. Oil	±8	±5	±8	±7
1.B.2.b. Natural gas	±9	±9	NA	±9
1.B.2.c. Venting and flaring	±4	±4	±4	±4

(a) Uncertainty reported at 95% confidence limits estimated using Latin Hypercube analysis.

A2.2 Industrial Processes

An analysis of uncertainty was conducted using the methods and random sampling techniques described in IPCC 2006. Uncertainty estimates of the components of each emission estimate (activity levels and emission factors) are based on expert judgement.

As the IPCC tier 1 approach is not suitable for assessing uncertainty where approximately normal distribution assumptions cannot be sustained, an analysis was undertaken using Latin Hypercube techniques. These techniques can take into account asymmetric probability distributions associated with emission factors. For example, as the average emission factor for PFCs tends to the minimum limit that is understood to be technically feasible, the probability of the emission factor being lower than estimated is less than the probability of it being higher than estimated.

The Latin Hypercube analysis gave an uncertainty of $\pm 5\%$ (Table A2.7). The uncertainty in the *industrial processes* subsectors ranged from $\pm 4\%$ to $\pm 20\%$.

Table A2.7: Quantified uncertainty values for key industrial processes subsectors using different techniques

Source	Uncertainties and distribution ^(a)		Emission factors – uncertainties and distributions								
	Production/ use	Distribution	CO ₂	Distribution	CH ₄	Distribution	N ₂ O	Distribution	CF ₄	Distribution	C ₂ F ₆
Cement clinker	±5.00	Normal	±4.99	Normal	NA	NA	NA	NA	NA	NA	NA
Cement kiln dust	±7.01	Normal	±5.01	Normal	NA	NA	NA	NA	NA	NA	NA
Cement total organic carbon	NA	Normal	±5.00	Normal	NA	NA	NA	NA	NA	NA	NA
Commercial lime	±5.00	Normal	±4.99	Normal	NA	NA	NA	NA	NA	NA	NA
In-house lime	±4.01	Normal	±5.01	Normal	NA	NA	NA	NA	NA	NA	NA
Limestone use	±8.01	Normal	±5.00	Normal	NA	NA	NA	NA	NA	NA	NA
Dolomite use	±8.00	Normal	±4.99	Normal	NA	NA	NA	NA	NA	NA	NA
Soda ash production	±5.00	Normal	NA	Stoichiometry	NA	NA	NA	NA	NA	NA	NA
Soda ash use	±5.00	Normal	NA	Stoichiometry	NA	NA	NA	NA	NA	NA	NA
Magnesia	±5.00	Normal	±5.00	Normal	NA	NA	NA	NA	NA	NA	NA
Ammonia	±7.02	Normal	±5.00	Normal	NA	NA	NA	NA	NA	NA	NA
Nitric acid	±10.00	Normal	NA	NA	NA	NA	±9.99	Normal	NA	NA	NA
Nitrous oxide	±5.00	Normal	NA	NA	NA	NA	NA	NA	NA	NA	NA
Synthetic rutile	±5.00	Normal	±5.00	Normal	NA	NA	NA	NA	NA	NA	NA
Titanium dioxide	±20.00	Normal	±5.00	Normal	NA	NA	NA	NA	NA	NA	NA
Iron and steel	±5.01	Normal	±2.05	Triangular	±3.82	Triangular	±16.33	Triangular	NA	NA	NA
Hot briquetted iron	±5.00	Normal	±4.08	Triangular	±4.34	Triangular	±9.07	Triangular	NA	NA	NA
Aluminium	±5.01	Normal	±5.00	Normal	NA	NA	NA	NA	±16.22	Triangular	Function of CF ₄

(a) Uncertainty reported at 95% confidence limits assuming approximately normal distributions. Source: Burnbank Consulting 2007.

A2.3 Agriculture

An uncertainty analysis was undertaken for the *agriculture* subsectors using the approach 1 propagation of error method. The uncertainties applied to activity data and emission factors were based on IPCC (2006) uncertainty estimates and expert judgement (see Table A2.8). It is planned in the future to develop approach 2 uncertainty estimates to better reflect data correlations and the complex tier 2 functions used to estimate emissions.

Table A.2.8: Relative uncertainty in emission estimates for the livestock subsector

Greenhouse gas source and sink categories	Uncertainty (%)		
	CH ₄	N ₂ O	CO ₂
A. Enteric fermentation	22		
B. Manure management	37	55	
C. Rice cultivation	11		
D. Agricultural soils		56	
E. Prescribed burning of savannas Burning	47	48	
F. Agricultural residue burning	38	38	
G. Liming			54
H. Urea application			51

A2.4 Land Use, Land Use Change and Forestry

Uncertainty analysis for the LULUCF sector was undertaken using the IPCC Approach 1, propagation of error method as described in IPCC 2006.

Forest land

In the sub-sector *forest land remaining forest land* activity data is derived from national statistics of forest harvesting (ABARES 2014). The uncertainty of these activity data has not been published and so is estimated to be $\pm 10\%$. The uncertainties regarding the emission factor used are also unpublished and are estimated to be $\pm 30\%$.

In the sub-sector land converted to forest land the uncertainty associated with the detection of forest cover gains is reported to be $\pm 3.5\%$ (see Appendix 6.A). Field sampling results presented by Paul et al. 2014 indicate an uncertainty of $\pm 11.5\%$ for the estimation of standing biomass.

Cropland remaining cropland

Cropland remaining cropland activity data are derived from ABS reporting of agricultural management practices as a regional level. The uncertainty associated with these reported activity data is estimated to be $\pm 20\%$ and the uncertainty associated with model results is estimated to be $\pm 20\%$.

Grassland remaining grassland

Grassland remaining grassland activity data are derived from ABS reporting of agricultural management practices as a regional level. The uncertainty associated with these reported activity data is estimated to be $\pm 20\%$ and the uncertainty associated with model results is estimated to be $\pm 20\%$.

Land converted to cropland and grassland

Remote sensing data are also used to supply activity data for these classifications and the uncertainty in these data is reported to be $\pm 3.5\%$. The key input variable to the estimation of biomass at the time of forest conversion to other land uses is the initial assumed above ground biomass. Based on data presented by Richards and Brack

(2004) uncertainty in this parameter is estimated to be +/-25%.

Harvested wood products

The harvested wood products model uses the same source of activity data as the *forest land remaining forest land* model. Uncertainties associated with these activity data are estimated to be +/-10%. Estimated uncertainty associated with the harvested wood products carbon stock change were derived as reduced form outputs of monte carlo analyses (see chapter 6.13) providing an uncertainty of +/-20%.

Table A2.9: Estimation of uncertainties in components of the land use change and forestry subsectors

Greenhouse gas source and sink categories	Uncertainty (%)		
	CO ₂	CH ₄	N ₂ O
A.1 Forest land remaining forest land	± 33.5	-46 +77	-47 +88
A.2 Land converted to forest land	± 11.5		
B.1/C.1 Cropland/Grassland remaining	± 28.3		
B. 2/C.2 Forest land converted to Cropland/Grassland	± 27.3	± 20	± 20

A2.5 Waste

Estimates for uncertainty for emissions from solid waste disposal were estimated by Burnbank Consulting. The full implications of non-linearities in the solid waste methodology are still to be satisfactorily explored, however, and further work into the solid waste estimates are likely in future.

Table A2.10: Relative uncertainty in emission estimates for key waste subsectors

Greenhouse gas source and sink categories	Uncertainty (%)				
	CH ₄	N ₂ O	NO _x	CO	NMVOC
6. Waste					
A. Solid waste disposal on land ^(a)	± 3.25	NA	NA	NA	NA
B. Wastewater	± 50				
C. Incineration	NA				

(a) Source Burnbank Consulting 2007

Table A2.11: Specific distributions, parameters and results: Solid Waste

Variable	Distribution and parameters	2sd	M-2sd	M+2sd	2sd/M	M-/2.5%	M+/97.5%
Emission Generated / 2004 – ACT		0.70	12.85	14.26	5.19%	1.00	1.00
Emission Generated / 2004 – NSW		16.55	277.85	310.95	5.62%	1.00	1.00
Emission Generated / 2004 – NT		0.26	4.63	5.14	5.26%	1.00	1.00
Emission Generated / 2004 – QLD		7.84	163.61	179.30	4.57%	1.00	1.00
Emission Generated / 2004 – SA		4.92	45.95	55.79	9.68%	1.00	1.00
Emission Generated / 2004 – TAS		1.72	15.75	19.19	9.84%	1.00	1.01
Emission Generated / 2004 – VIC		16.57	163.14	196.29	9.22%	1.00	1.00
Emission Generated / 2004 – WA		8.94	78.13	96.01	10.27%	1.00	1.00
Emissions Generated – Australia		26.59	792.84	846.03	3.25%	1.00	1.00
DOCfood	Normal (0.15,0.05*0.15)	0.01	0.13	0.16	10.00%	1.00	1.00
DOCpaper&text / DOCpaper&text	Normal (0.4,0.05*0.4)	0.04	0.36	0.44	10.00%	1.00	1.00
DOGarden / DOGarden	Normal (0.17,0.05*0.17)	0.02	0.15	0.19	10.00%	1.00	1.00
DOCwood / DOCwood	Normal (0.43,0.05*0.43)	0.04	0.39	0.47	10.00%	1.00	1.00
Standard Mix – MSW- food	Triangle (0.15,0.21,0.27)	0.05	0.16	0.26	23.33%	0.99	1.01
Standard Mix – MSW-p&t / Standard Mix – MSW-p&t	Triangle (0.07,0.11,0.15)	0.03	0.08	0.14	29.69%	0.98	1.01
Standard Mix – MSW-gg / Standard Mix – MSW-gg	Triangle (0.14,0.19,0.24)	0.04	0.15	0.23	21.49%	0.99	1.01
Standard Mix – MSW-wood / Standard Mix – MSW-wood	Triangle (0.02,0.03,0.04)	0.01	0.02	0.04	27.22%	0.98	1.01
Standard Mix – MSW-other / Standard Mix – MSW-other	Triangle (0.38,0.46,0.54)	0.07	0.39	0.53	14.20%	0.99	1.01
DDOC	Normal(0.5,0.1*0.5)	0.10	0.40	0.60	20.00%	1.00	1.00
Half-life	Triangle (3,4,6)	1.25	3.09	5.58	28.78%	0.94	0.99
Half-life	Triangle (10,12,14)	1.63	10.37	13.63	13.61%	0.99	1.01
Half-life	Triangle (6,7,9)	1.25	6.09	8.58	17.01%	0.97	1.00
Half-life	Triangle (17,23,35)	7.48	17.52	32.48	29.93%	0.94	0.99
Time Delay	Normal(7,0.28*7)	3.92	3.08	10.92	55.99%	0.98	1.01
Half-life	Triangle (3,4,6)	1.25	3.09	5.58	28.78%	0.94	0.99
Half-life	Triangle (10,12,14)	1.63	10.37	13.63	13.61%	0.99	1.01
Half-life	Triangle (6,7,9)	1.25	6.09	8.58	17.01%	0.97	1.00
Half-life	Triangle (17,23,35)	7.48	17.52	32.48	29.93%	0.94	0.99
Time Delay	Normal(7,0.28*7)	3.92	3.08	10.92	56.00%	0.98	1.01

Variable	Distribution and parameters	2sd	M-2sd	M+2sd	2sd/M	M-/2.5%	M+/97.5%
Half-life	Triangle (1,2,4)	1.25	1.09	3.58	53.45%	0.85	0.99
Half-life	Triangle (8,10,12)	1.63	8.37	11.63	16.33%	0.99	1.01
Half-life	Triangle (3,4,5)	0.82	3.18	4.82	20.41%	0.99	1.01
Half-life	Triangle (14,20,23)	3.74	15.26	22.74	19.69%	1.01	1.03
Time Delay	Normal(7,0.28*7)	3.92	3.08	10.92	55.99%	0.98	1.01
Half-life	Triangle (1,2,4)	1.25	1.09	3.58	53.45%	0.85	0.99
Half-life	Triangle (8,10,12)	1.63	8.37	11.63	16.33%	0.99	1.01
Half-life	Triangle (3,4,5)	0.82	3.18	4.82	20.41%	0.99	1.01
Half-life	Triangle (14,20,23)	3.74	15.26	22.74	19.69%	1.01	1.03
Time Delay	Normal(7,0.28*7)	3.92	3.08	10.92	56.00%	0.98	1.01
Half-life	Triangle (9,12,14)	2.05	9.61	13.72	17.61%	1.00	1.02
Half-life	Triangle (14,17,23)	3.74	14.26	21.74	20.79%	0.96	1.00
Half-life	Triangle (12,14,17)	2.05	12.28	16.39	14.34%	0.98	1.00
Half-life	Triangle (23,35,69)	19.48	22.85	61.82	46.02%	0.86	0.99
Time Delay	Normal(7,0.28*7)	3.92	3.08	10.92	55.99%	0.98	1.01
Half-life	Triangle (9,12,14)	2.05	9.61	13.72	17.61%	1.00	1.02
Half-life	Triangle (14,17,23)	3.74	14.26	21.74	20.79%	0.96	1.00
Half-life	Triangle (12,14,17)	2.05	12.28	16.39	14.34%	0.98	1.00
Half-life	Triangle (23,35,69)	19.48	22.85	61.82	46.02%	0.86	0.99
Time Delay	Normal(7,0.28*7)	3.92	3.08	10.92	56.00%	0.98	1.01
Half-life	Triangle (9,12,14)	2.05	9.61	13.72	17.61%	1.00	1.02
Half-life	Triangle (14,17,23)	3.74	14.26	21.74	20.79%	0.96	1.00
Half-life	Triangle (12,14,17)	2.05	12.28	16.39	14.34%	0.98	1.00
Half-life	Triangle (23,35,69)	19.48	22.85	61.82	46.02%	0.86	0.99
Time Delay	Normal(7,0.28*7)	3.92	3.08	10.92	55.99%	0.98	1.01
Half-life	Triangle (9,12,14)	2.05	9.61	13.72	17.61%	1.00	1.02
Half-life	Triangle (14,17,23)	3.74	14.26	21.74	20.79%	0.96	1.00
Half-life	Triangle (12,14,17)	2.05	12.28	16.39	14.34%	0.98	1.00
Half-life	Triangle (23,35,69)	19.48	22.85	61.82	46.02%	0.86	0.99
Time Delay	Normal(7,0.28*7)	3.92	3.08	10.92	55.99%	0.98	1.01

Source: Burnbank Consulting 2007

ANNEX 3: Other Detailed Methodological Descriptions

The Australian methodology for the estimation of this inventory is documented in the relevant chapters.

ANNEX 4: Carbon Dioxide Reference Approach for the Energy Sector

A4.1 Estimation of CO₂ Using the IPCC Reference Approach

The reference approach estimates CO₂ emissions from *fuel combustion activities* (covering both *stationary energy* and *transport*). It is calculated using a top-down approach based on national energy statistics for production, imports, exports and stock change. Data are obtained from BREE Australian national resource and energy statistics, supplemented by specific sectoral data where available. The Australian Petroleum Statistics are used as a basis for the liquid fossil fuel data.

A4.2 Comparison of Australian Methodology with IPCC Reference Approach

Total CO₂ emissions estimated using Australia's national approach methodology are 367.4 Mt. Total CO₂ emissions estimated using the reference approach are 370.9 Mt – this is a 0.9% difference between the two methods.

ANNEX 5: Assessment of Completeness

The UNFCCC guidelines require inventory compilers to assess inventories for the level of completeness of national inventories. The sources of greenhouse gas emissions are many and diverse and, in general, are not directly observable without considerable cost. Many emission sources are minor and resource intensive to estimate. Consequently, all national inventories have minor omissions which, for transparency, need to be identified. This section addresses the completeness of key activity datasets, such as the consumption of fossil fuels, and the completeness of the coverage of emissions and removals sources for the Australian inventory.

A5.1 Completeness of Activity Data

The emission estimates were reviewed for internal consistency and completeness through the application of mass balance approaches to ensure the reconciliation of carbon supplies and carbon uses within the economy for fossil fuels, carbonates and biomass entering the economy. Details have been provided in the respective sectoral chapters. An overview of the mitigation strategies and control measures adopted, monitoring mechanisms employed and quality objectives or targets results specified is provided in Annex 6.

A5.2 Omitted Emission Sources

The UNFCCC reporting guidelines provide standard reporting templates that are designed to accommodate the circumstances of as many countries as possible. The reporting templates are not always closely aligned with Australia's circumstances. Consequently, in Australia's reporting tables there are a number of categories where the term "not occurring" has been reported for certain cells because of an absence of a certain economic activity. An example is *adipic acid* production, which does not occur in Australia.

Nonetheless, there are a small number of emission sources which are believed to be minor and which are reported as 'not estimated' either because of a lack of data or because the emission processes are not well enough understood to permit the development of reliable methodologies. In these instances, default methodologies are not specified by the IPCC due to limited understanding internationally of these processes. One example is CO₂ from Burning of Coal Deposits and Waste Piles (1B1). The spontaneous combustion of waste piles is a known source of CO₂ emissions. Research undertaken on the measurement of this emission source has not yet been able to develop any reliable approach to the estimation of this emission source. The *2006 IPCC Guidelines* do not include a default methodology that could be applied in the absence of information on this source.

The UNFCCC reporting guidelines (FCCC/CP/2013/10/Add.3) also allow minor emission sources to be reported as "not estimated" where a disproportionate amount of effort would be required to collect data for a category that would be insignificant in terms of the overall level and trend in national emissions (i.e. <0.05% of national emissions excluding LULUCF and not exceeding 500 kt CO₂-e). The sources reported as NE under this provisions are 1.A.3B.vi urea-based catalysts and 3.D.1.d *other organic fertilisers*.

The use of urea based additives (diesel emissions fluid DEF) in catalytic converters is occurring in Australia. A certain proportion of heavy vehicles and passenger vehicles designed to meet Euro 5 emission standards are equipped with engine emission control systems using selective catalyst reduction (SCR) technology. There is no data of DEF consumption in Australia and this would be difficult to collect. To assess the significance of this source, we have made some conservative assumptions. The vast majority of DEF consumption will be in the heavy vehicle fleet. In Australia, around 4 million kL of diesel fuel is consumed by heavy vehicles. With manufactures of heavy diesel engines citing around 2% consumption of DEF to diesel and if it was assumed that every Euro 5 compliant heavy vehicle used SCR technology, there would be around 3000 tonnes of CO₂ attributed to

urea-based catalysts, which is well below the amount that can be considered insignificant (the threshold being 2710 kt CO₂-e.).

The organic fertilisers used in Australia are principally derived from animal wastes. Emissions from this organic N source are covered elsewhere. Data on the application of other organic N fertiliser is not available through either ABS or industry data collections. Nor is a comprehensive list of organic fertiliser producers available. To assess the significance of the category, data was sourced from one of the largest commercial producer. They reported production of meat and fish meal containing 117.8 tonnes N. Applying the IPCC default EF of 1% this give emissions of 0.55kt CO₂-e. Even allowing for the complete estimate to be over 4500 time greater, this category can be considered insignificant (threshold being 2710 kt CO₂-e.).

ANNEX 6: Additional Information: Quality Controls including Australia's National Carbon Balance

A6.1 Additional information on the QA/QC Plan

The management of the QA/QC activities relating to the inventory are undertaken by the National Inventory Team within DE and detailed in the *National Greenhouse Accounts: Quality Assurance-Quality Control Plan*. An overview of the quality control system is provided in Chapter 1 while sector-specific information on quality control activities has been included in the QA/QC sections of each chapter. This Annex provides additional information and, in particular, provides information in relation to three aspects of the quality control system: i) a detailed description of the quality control measures in place; ii) results of the carbon balance for the economy; and iii) a description of Australia's responses to the recommendations contained in the previous UNFCCC ERT report.

The objectives of the national inventory quality system are to support the provision of emission estimates that meet the UNFCCC criteria of accuracy; time series consistency; transparency, completeness and comparability of estimates with those of other parties.

Key risks to the attainment of the defined quality objectives are identified at each level of inventory preparation including the measurement of data at the facility level; the collation of activity and other input data by DE and other agencies; and the process of emissions estimation.

Specified mitigation strategies, measures and routine actions are deployed to control the identified risks.

These strategies range from utilisation of data measurements governed by existing national measurement systems such as the National Measurement Act or various taxation acts to the use of automated quality control tools embedded in the Australian Greenhouse Emissions Information System (AGEIS). Principal mitigation strategies and control measures are set out in table A6.1.

Monitoring of the quality measures and evaluation of the results are critical to the goal of maintaining the system's effectiveness. In particular, control measures include the use of mass balance checks for all years to assess completeness and accuracy. All carbon entering the market economy is accounted for – either as emissions or stored in products or stored in wastes. Carbon balances for fuels, biomass, carbonates and synthetic gases consumption have been constructed and the results presented as Australia's National Carbon Balance in table A6.2.

In response to a recommendation by the previous UNFCCC ERT reports, models have been developed to demonstrate the flows of fugitive methane and carbon dioxide associated with underground and surface coal mines. The underground coal mine model shown in figure A6.2 also demonstrates the effectiveness of methane capture for electricity generation and flaring in reducing the net fugitive emissions – capturing 42% of the gross methane generated from underground coal mining.

External review of the inventory is a critical part of the process of ensuring the quality of the estimates. In principle, the Australian inventory is subject to audit by the Australian National Audit Office (ANAO), and a performance audit was conducted by the ANAO in 2009–10. In addition, each year the inventory is reviewed by international experts organised as part of the UNFCCC expert review team process. In tables A6.6a to A6.6e, the recommendations of previous UNFCCC ERT reports have been included for increased transparency and a summary of Australia's responses included. These tables provide a tool for tracking the management of the ERT recommendations and suggestions.

Table A6.1: Summary of principal mitigation strategies and quality control measures

Measure No.	Quality objective	Mitigation strategy or control measure	Target	Monitoring mechanism	2006 IPCC Guidelines Vol 1 cross reference
Measurement					
1.A.1	Accuracy, completeness and time series consistency	National emissions reporting system subject to national measurement system and Australian regulations and international standards as specified in the NGER Measurement Determination 2008	Compliance	DE	6.7.2.2, page 6.16
1.A.2	Accuracy	Data submitted under NGER subject to Clean Energy Regulator validation unit activities	Compliance	DE	6.7.2.2, page 6.16
1.B.1	Comparability	Integration of national and facility estimation methods within National Greenhouse Accounts Framework	Compliance	DE	6.7.1.2 page 6.12
1.D.1	Transparency	Company level data published by the Clean Energy Regulator under the NGER Act 2007	Compliance	DE	6.5, page 6.8
Collated data used for national emissions estimation					
2.A.1	Accuracy	Comparison of energy data with independent sources of activity data	<2%	AGEIS Automated Report	6.7.2.1, page 6.15
2.A.2	Accuracy	External consultants operate QC protocol	Compliance	National Inventory Team	6.4, page 6.16
2.A.3	Accuracy	Quality control systems for external data providers	Compliance	Agency governance boards	6.4, page 6.16
2.B.1	Completeness	Application of standardised rules for use of facility level data in national inventory	Compliance	National Inventory Team	Table 6.1, page 6.11; Section 6.7.2.1, page 6.15
2.B.2 (i)	Completeness	Reconciliation of estimates of carbon in fuel supplies to the Australian economy and carbon contained in emissions; or stored in products; or non-oxidised; or in permanent storage	<0.1%	AGEIS Automated Report	Table 6.1, page 6.11; Section 6.7.2.1, page 6.15
2.B.2 (ii)	Completeness	Reconciliation of estimates of carbon in carbonate supplies to the Australian economy and carbon contained in emissions; or stored in products; or waste residues or in permanent storage	<0.1%	AGEIS Automated Report	Table 6.1, page 6.11; Section 6.7.2.1, page 6.15
2.B.2 (iii)	Completeness	Reconciliation of estimates of carbon in biomass supplies to the Australian economy and carbon contained in emissions or stored in products or waste residues or in permanent storage	<1%	AGEIS Automated Report *	Table 6.1, page 6.11; Section 6.7.2.1, page 6.15

Measure No.	Quality objective	Mitigation strategy or control measure	Target	Monitoring mechanism	2006 IPCC Guidelines Vol 1 cross reference
2.B.2 (iv)	Completeness	Reconciliation of estimates of carbon in wastewater to the Australian economy and carbon contained in emissions or stored in products or waste residues or in permanent storage	<1%	AGEIS Automated Report *	Table 6.1, page 6.11; Section 6.7.2.1, page 6.15
2.B.2 (v)	Completeness	Reconciliation of estimates of nitrogen in wastewater to the Australian economy and nitrogen contained in emissions or stored in products or other by-products	<1%	AGEIS Automated Report *	Table 6.1, page 6.11; Section 6.7.2.1, page 6.15
2.B.2 (vi)	Completeness	Reconciliation of estimates of carbon in synthetic gases supplied to the Australian economy and synthetic gases contained in emissions or stored in products or destroyed	<1%	AGEIS Automated Report *	Table 6.1, page 6.11; Section 6.7.2.1, page 6.15
2.B.2 (vii)	Completeness	Reconciliation of estimates of natural gas consumption in the Australian economy as reported by various data sources	<3%	National Inventory Team	Table 6.1, page 6.11; Section 6.7.2.1, page 6.15
National Emissions Estimation					
3.A.1	Accuracy	Emission estimation methodologies should be consistent with IPCC Good Practice and comparable with international practice	Compliance	NGGI Committee	IPCC Good Practice Guidance
3.A.2 (i)	Accuracy	AGEIS development in accordance with COBIT	Compliance	AGEIS Strategic Plan	AGEIS implementation report
3.A.2 (ii)	Accuracy	AGEIS operation in accordance with COBIT	Compliance	AGEIS Strategic Plan	AGEIS implementation report
3.A.2 (iii)	Accuracy	Allocation of separate staff roles and responsibilities	Compliance	AGEIS Strategic Plan	6.4, page 6.7
3.A.3	Accuracy	Validation of selected AGEIS estimates by sectoral experts	<0.01%	National Inventory Team	6.7.3, page 6.16
3.A.4	Accuracy	The estimated uncertainty of the overall inventory should decline over time	Compliance	National Inventory Team	6.9, page 6.18
3.B.1 (i)	Completeness	Reconciliation of fuel data submitted into the AGEIS and carbon contained in emissions or stored in products or non-oxidised or permanent storage	<0.001%	AGEIS Automated Report	Table 6.1, page 6.10; 6.7.3 page 6.16
3.B.1 (ii)	Completeness	Reconciliation of carbonate data submitted into the AGEIS and carbon contained in emissions or stored in products or waste residues or in permanent storage	<0.001%	AGEIS Automated Report	Table 6.1, page 6.10; 6.7.3 page 6.16
3.B.1 (iii)	Completeness	Reconciliation of biomass data submitted into the AGEIS and carbon contained in emissions or stored in products or waste residues or in permanent storage	<0.001%	AGEIS Automated Report	Table 6.1, page 6.10; 6.7.3 page 6.16

Measure No.	Quality objective	Mitigation strategy or control measure	Target	Monitoring mechanism	2006 IPCC Guidelines Vol 1 cross reference
3.B.1 (iv)	Completeness	Reconciliation of carbon in synthetic gases in data submitted into the AGEIS and carbon contained in emissions or stored in products or destroyed	<0.001%	AGEIS Automated Report *	Table 6.1, page 6.10; 6.7.3 page 6.16
3.B.2 (i)	Completeness	Reconciliation of National Inventory with aggregate of State and Territory inventories	<0.1%	AGEIS Automated Report	Table 6.1, page 6.10; 6.7.3 page 6.16
3.B.2 (ii)	Completeness	Reconciliation of the National Greenhouse Gas Inventory with the National Inventory by Economic Sector	<0.1%	AGEIS Automated Report	6.7.2.1, page 6.14
3.B.2 (iii)	Completeness	Reconciliation of the National Greenhouse Gas Inventory against OLAP output from the AGEIS database	<0.1%	AGEIS Automated Report	Table 6.1, page 6.10
3.B.3	Completeness	Number of emission sources 'not estimated', for which IPCC methods exist, comparable with international practice	Compliance	DE assessment of UNFCCC ERT report	6.7.2.1, page 6.14
3.B.4	Completeness	Number of significant completeness issues should reduce over time	Compliance	DE assessment of UNFCCC ERT report	6.8, page 6.18
3.C.1	Comparability	Implied emission factors for key variables should not be significantly different to those of other UNFCCC reporting parties	Compliance	AGEIS Automated Report	6.8, page 6.18
3.C.3	Comparability	Recalculation percentages for the national inventory Annex A sectors should not be significantly different to those of other UNFCCC reporting parties over time	Compliance	AGEIS automated report	6.8, page 6.18
3.C.4	Comparability	Implied emission factors for key variables should not be significantly different to those of available plant-specific data	Compliance	AGEIS Automated Report	6.7.1.2, page 6.13
3.D.1	Time series	Analysis by category for time series consistency	Compliance	AGEIS automated report	Table 6.1, page 6.11
3.D.2	Time series	The number of significant time-series consistency issues raised by the UNFCCC ERT, and agreed by the DE, should reduce over time	Compliance	DE assessment of UNFCCC ERT report	Table 6.1, page 6.11
3.E.1	Transparency	Publication of assumptions, methodologies, data sources and emission estimates in the National Inventory Report and related products	Compliance	National Inventory Team	6.5, page 6.8
3.E.2	Transparency	Publication of the AGEIS emissions database on the DE website	Compliance	National Inventory Team	6.5, page 6.

* Planned for AGEIS implementation 2013-14.

A6.2 Australia's National Carbon Balance

Table A6.2: Australia's National Carbon Balance 2012

Supply	Kt C	Uses	Kt C
Fossil fuel consumption* (a)	109,606	<i>Emissions</i>	
Carbonate consumption (a)	2,001	1.A Combustion emissions (fossil fuels)	100,197
Hydrofluorocarbon consumption (d)	4,032	1.B Fugitive emissions	186
		2.A Industrial process fossil fuel emissions	3,947
		Memo: International bunker fuels	3,384
		2.A Mineral product carbonate emissions	1,959
Biomass consumption		2.F Hydrofluorocarbon emissions (d)	2,711
Wood and paper products (a)	4,394	Memo: Combustion emissions (wood products and waste)	526
Bagasse, ethanol, biogas (b)	2,841	Memo: Combustion emissions (bagasse, ethanol, biogas)	2,836
Firewood (b)	1,124	Memo: Combustion emissions (all wood)	2,048
		5.A Landfill emissions from HWP	466
Waste disposal (food, garden, textiles, rubber – landfill)(c)	1,201	5.A Landfill emissions from non-HWP	684
		Aerobic treatment processes (paper, wood and wood waste)	192
		<i>Increment to product stocks</i>	
		Petrochemical and steel products	95
		Carbonate products	3
		Hydrofluorocarbon products (d)	1,200
		Increment to HWP stocks	1,078
		Biomass fibre recycled	1,768
		<i>Increment to waste stocks and residues</i>	
		Carbon dioxide captured for permanent storage	0
		Non-oxidised carbon*	873
		Carbonate wastes	46
		Increment to HWP waste in landfill	363
		Increment to non-HWP waste in landfill	517
		<i>Miscellaneous</i>	
		Hydrofluorocarbons destroyed	121
		Residual	-2
Total supply	125,197	Total uses	125,197

Notes: (a) entering market; (b) final consumption; (c) entering waste stream; (d) based on carbon dioxide equivalents.

* Coal fuelled electricity generation assumes the NGRS oxidation factor of less than 100% oxidation.

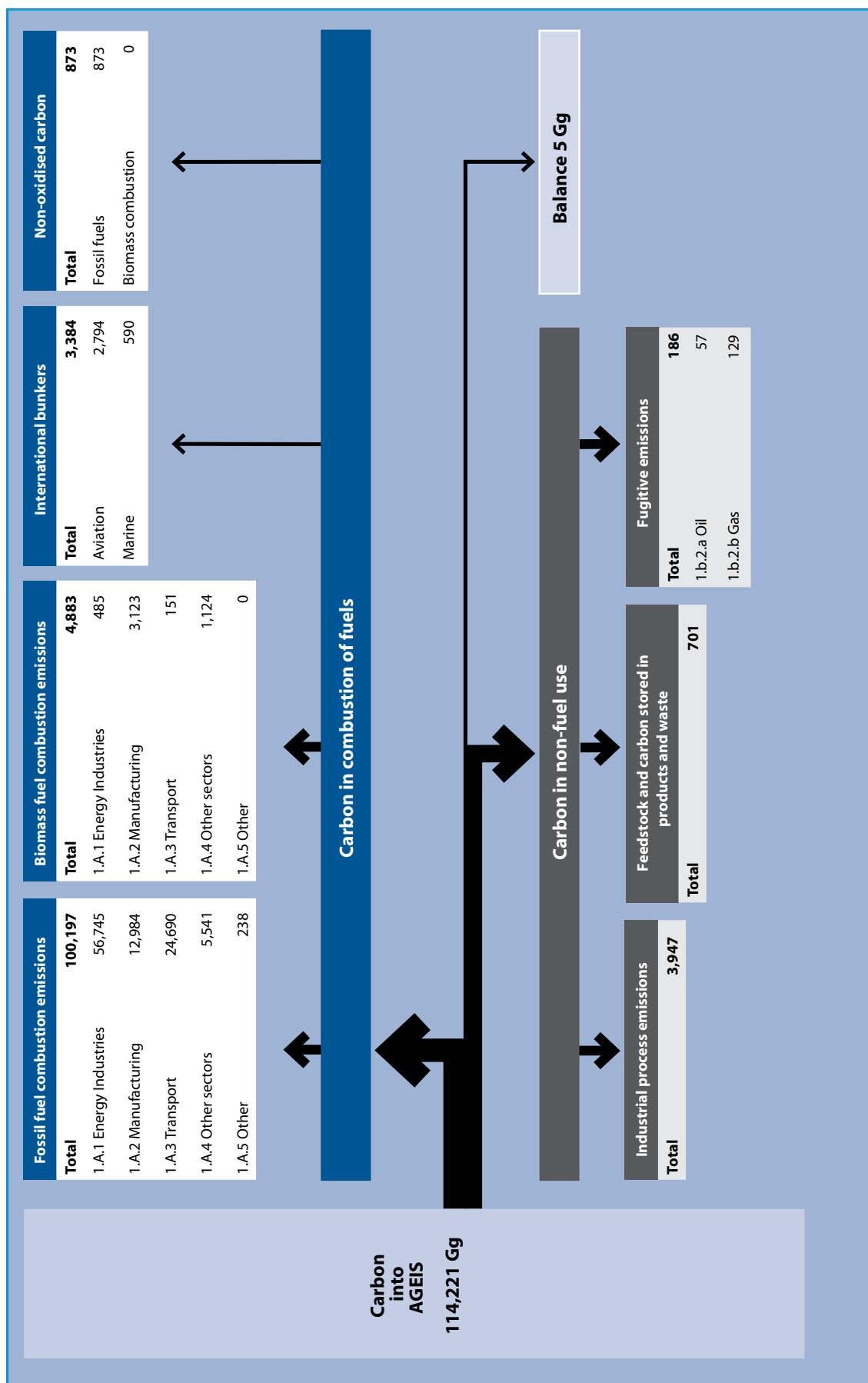
Australia's National Carbon Balance records the supply of carbon entering the market economy through the most important channels and tracks the uses or fates of that carbon allocated amongst greenhouse emissions, increments to the stock of carbon in products and increments to the stock of carbon in waste residues. Of the 125,197 kt C of carbon entering the market economy, 119,135 kt C is estimated to result in greenhouse gas emissions; 4,145 kt C is estimated to result in increments of the carbon stock in products and 1,799 kt C is estimated to result in increments to carbon stored in waste product and residues.

Assessments of the total amount of carbon in stock are more difficult to assess and depend critically on starting assumptions. Bearing this in mind, it is estimated that there is approximately 102 Mt of carbon stored in harvested wood products in Australia and about the same amount again stored in landfills. The latter estimate relies on the relatively strong assumption that all landfills have been maintained in order to fulfil anaerobic conditions. If the alternative assumption was adopted, such that it was assumed that all landfills were eventually exposed to aerobic conditions, then the amount of carbon stored in landfills would tend to zero over very long time periods.

The National Carbon Balance is also used as a quality control tool. The Australian inventory utilises a very large number of disaggregated data inputs for energy-related emission calculations (~15 000 per year). Consequently, a carbon balance is undertaken to compare carbon input to carbon output for all years. The carbon input represents the carbon embodied within the total quantity of energy and non-energy fuels which have been consumed in a year, and are entered into the AGEIS for calculation. The carbon output represents the distribution of the carbon utilised throughout the economy, as determined by the output of the calculations within the AGEIS. The carbon output is distributed as either emissions from fuel combustion, emissions from the use of fossil fuels as reductants, non-energy uses (e.g. feedstocks, bitumen, coal oils and tar), use of biomass sources of energy and international bunkers. While the predominant outcome of carbon entering the economy is emissions, a small portion of the carbon is stored in carbon-containing products or non-oxidised as ash. A flow chart detailing the results of the carbon balance for 2013 is at figure A6.1.

Results from the carbon balance have shown that all carbon is effectively accounted for. For 2013, all carbon has been accounted for down to 0.002%. This discrepancy relates to carbon contained in carbon dioxide from carbonates and biofuels within the memo items. Further work will continue on resolving this discrepancy.

Figure A6.1: Balance flow chart showing carbon inputs and distribution of outputs for 2013*



* Carbon into AGEIS include CO₂ captured for temporary storage and transfer offsite

Figure A6.2: Fugitive gas balance flow chart for underground mines, 2013

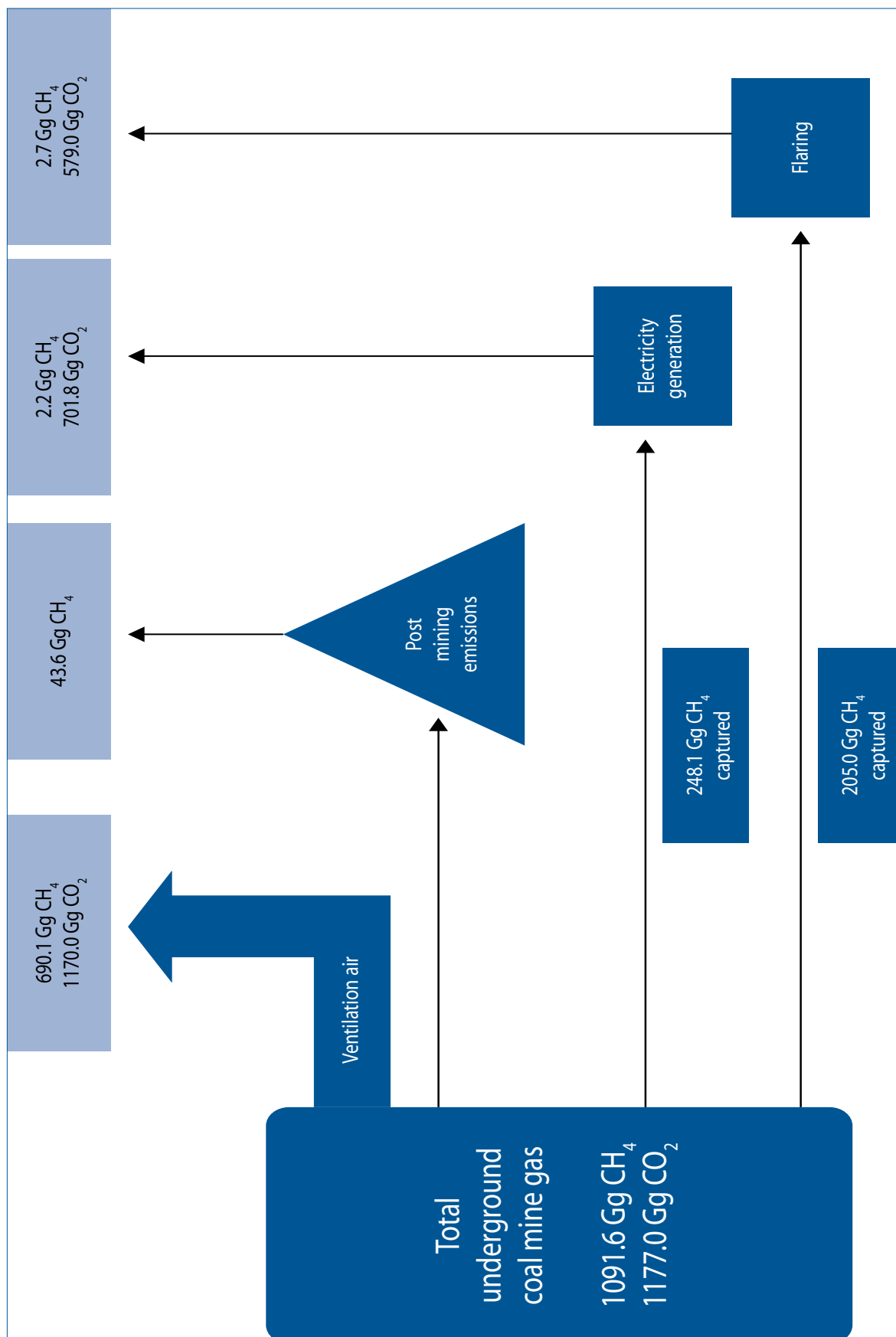


Figure A6.3: Fugitive gas balance flow chart for open cut mines, 2013

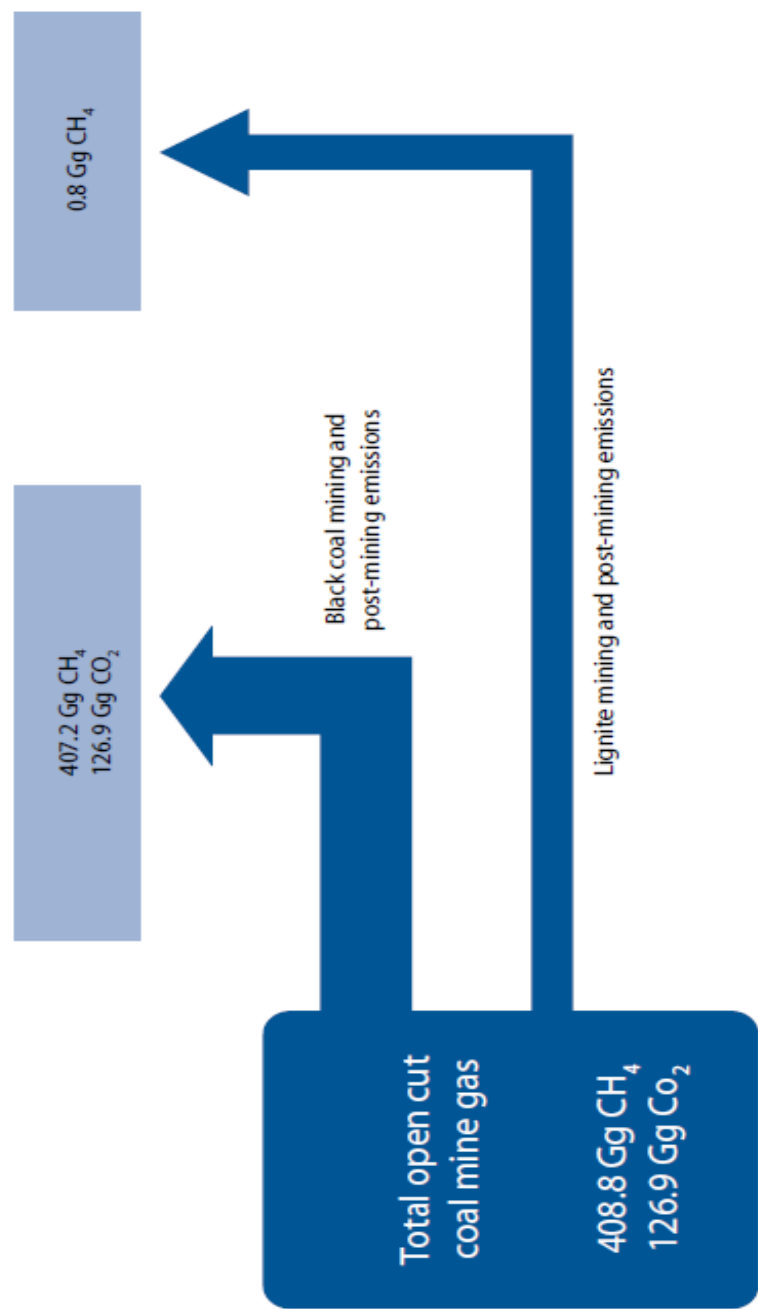


Table A6.3: Underground mining raw coal production, by coal field

Year	Coal Production by Basin (tonnes of production)							
	HUNTER	NEWCASTLE	WESTERN	SOUTHERN	BOWEN CENTRAL	BOWEN NORTHERN	BOWEN SOUTHERN	QLD SOUTHERN
1990	4,344,800	18,971,900	8,685,300	17,771,200	5,173,984	684,542	591,808	523,410
1991	4,848,129	18,435,910	9,433,269	18,134,150	6,549,461	659,348	635,513	779,744
1992	5,197,075	18,423,863	7,806,943	18,071,525	8,175,110	508,221	548,438	595,156
1993	4,622,113	17,705,992	9,947,807	17,566,298	8,782,642	589,456	632,108	692,298
1994	3,371,283	16,824,755	10,377,687	16,217,123	10,711,371	1,159,564	629,277	618,883
1995	6,364,090	16,061,104	11,613,380	14,663,729	13,172,078	2,564,908	0	687,236
1996	9,192,400	16,804,600	13,002,300	15,314,900	10,992,009	1,612,780	0	597,411
1997	10,813,245	15,346,470	12,697,898	15,784,757	13,756,322	3,846,835	0	558,769
1998	14,144,563	16,783,447	12,010,638	15,360,353	19,158,765	4,543,003	0	0
1999	13,680,481	13,664,985	10,860,591	13,112,341	20,290,940	7,398,073	0	0
2000	15,252,463	15,257,326	10,447,917	11,805,638	25,006,028	13,169,231	0	0
2001	14,589,035	13,751,733	12,775,399	12,602,477	27,105,717	11,214,891	0	0
2002	13,081,548	13,831,303	12,984,571	12,693,281	26,580,624	12,196,246	0	0
2003	12,257,057	10,842,531	12,683,711	11,174,159	23,111,145	11,661,140	0	0
2004	16,582,600	11,412,069	10,924,964	10,434,890	22,058,438	9,618,348	0	0
2005	15,207,383	10,901,574	13,655,101	12,142,786	22,731,234	11,953,481	0	0
2006	15,674,644	10,540,319	12,676,749	13,340,369	22,534,011	11,754,358	0	0
2007	16,875,285	14,023,563	12,929,478	13,412,166	21,268,729	14,351,067	0	0
2008	17,311,462	13,917,235	12,741,554	11,507,490	25,972,448	16,842,856	0	0
2009	19,245,169	14,552,747	16,562,805	12,707,969	24,262,219	16,778,503	0	0
2010	19,580,571	15,211,443	15,026,978	12,985,314	30,182,038	21,775,029	0	0
2011	16,028,421	16,016,035	15,827,685	14,261,975	28,099,846	17,056,976	0	0
2012	11,579,449	16,741,428	15,581,607	16,559,350	24,734,441	10,634,861	0	0
2013	18,719,469	17,286,254	16,927,198	16,059,422	26,869,534	19,811,148	0	0

Source: Queensland Department of Energy and Water, Coal Services Pty Ltd

Table A6.4: Australian Petroleum refining activity data

Year	Fuel type (PJ)		
	Solid	Liquid	Gas
1990	-	76.0	11.3
2000	-	80.1	18.6
2001	-	80.6	20.0
2002	-	78.9	20.7
2003	-	75.4	22.3
2004	-	67.0	22.7
2005	-	65.1	24.1
2006	-	56.1	24.6
2007	-	63.3	23.6
2008	-	60.7	22.8
2009	-	69.8	14.1
2010	-	71.0	12.5
2011	-	75.6	14.5
2012	-	68.8	17.6
2013	-	69.2	14.1

Source: Australian Energy Statistics and NGER

Carbon stock account for Australia's forests 2001–2010

Introduction

This summary of the carbon stock account for Australia's forests is adapted from material to be presented in *Australia's State of the Forests Report*.

Development of the carbon stock account for Australia's forests

The carbon stock accounts for Australia's forest have been derived under national inventory system. These estimates provide information for policy makers and act as a quality control tool which will be used to assess quality of inventory estimates.

Causes of carbon stock changes in forest systems

Major events that cause reductions in national carbon stocks that are monitored and estimated include:

- Harvest from production forests;
- Natural disturbance events such as fires; and
- Forest clearing.

Major events that cause increases in carbon pools include planting events. Major increases in carbon stocks also occur in forest lands that have been subject to past disturbance events such as harvest or fire; regrowth from harvest events may take 100 years for the regrowth trees to approach maturity.

Results of the carbon stocks analysis 2001–05 and 2006–10

The stock of carbon in Australia's forests in 2010 is estimated to be 12,841 Mt C (table A6.3). It is estimated that the stock of carbon in forests decreased by 81 Mt C (0.6 per cent) between 2001 and 2010. While these figures are indicative, time frames longer than one decade are needed to properly assess trends in carbon stocks in Australia's forests.

The key feature of this decade is the shift from a net loss of carbon in the period 2001–05 (91 Mt C) to a small net gain in the period 2006–10 (10 Mt C; table A6.3).

Key drivers of the decline in the period 2001–05 were wildfire (a loss of 93 Mt C) and reclassification to non-forest of land that lost its forest cover through clearing together with a change in land use (a loss of 97 Mt C) (table A6.3). In the period 2001–2005 the millennium drought had taken hold. With fuel loads that had built up over decades and the hot dry conditions due to the drought, wildfire caused a high loss of carbon from Australia's forests; especially in 2003.

Over the period 2006–10, the recovery of forest carbon stocks was driven by a combination of reduced reclassification of forest land to non-forest land, less wildfire losses, and growth in stock associated with recovery of forests following wildfires in the period 2001–05.

Carbon stock gains – Growth in stock

Over the period 2001–10, gross¹⁴ increases in carbon stocks in Australia's forests (due to tree growth and increases in the debris and soil pools) were estimated to be 416 Mt C (table A6.3). The majority of the gross carbon stock gains (357 Mt, 88 per cent) occurred in Australia's native forests (table A6.3). Gains in both plantations and native forests were slightly higher in the period 2006–10 compared to 2001–05 (table A6.3). The increased growth in carbon stock in native forests was likely due to forests regrowing after fire early in the decade, and the increased growth in carbon stock in plantations was likely due to the growth of young plantations following the peak planting period between 2000 and 2005.

Carbon stock gains – Reclassification to forest

The reclassification of land from grassland to forest appears as a gain in stock in the carbon accounts (table A6.3); however it does not represent a gain in carbon from the atmosphere. This item represents carbon stocks on the land transferred in to the forest land base. Thus, when a plantation is established on ex-agricultural land or when native forests regenerate naturally, all of the soil and debris carbon on that land is transferred into the forest land classification.

Carbon stock losses – Transfer to product pools

Transfer of carbon to product pools occurred at a relatively stable rate between 2001–05 and 2006–10 (table A6.3). There was a slight increase (from 34 per cent to 38 per cent) in the proportion of carbon transferred to the product pool that originated from plantations (table A6.3).

In the period 2001–10, an estimated 50 Mt of firewood was burned for heating, equivalent to the consumption of around 24.5 Mt of carbon.

Carbon stock losses – Managed losses

Managed losses are losses of carbon directly from forests to the atmosphere that are associated with the management of forests, for example prescribed burning or post-harvest burning. Post-harvest burning as part of native forest harvesting operations and for the purpose of fire suppression was estimated to cause the loss of approximately 15 Mt C in 2001–05 and 16 Mt C 2006–10. However, the largest source of carbon stock loss in this category occurs when forests are cleared for agriculture or other development. As part of this process, forest debris is generally burnt, resulting in a direct loss of greenhouse gases to the atmosphere.

¹⁴ Gross increases do not include losses to atmosphere (e.g. fire), transfers out of forest land (e.g. to harvested products), or land reclassification: which are detailed separately in Table A6.3.

No emissions from this source are recorded for plantation forests as part of this analysis. The carbon stock changes associated with post-harvest burning in plantations are included in the modelling of carbon stocks in these forests, and embedded in the overall carbon stock gain data from this source.

Carbon stock losses – Catastrophic losses

Losses of carbon stocks due to wildfire were 93 Mt C in 2001–05, and declined by 40 per cent to 55 Mt C in the period 2006–10. The higher losses of carbon stocks due to wildfire in the period 2001–05 were a key contributor to the net loss of carbon from Australia's forests recorded for that period. The lower carbon stock losses from this source in the period 2006–2010, and the carbon stock increase resulting from regrowth from fires in 2001–05, were key drivers of net increase in carbon stocks in Australia's forests in the period 2006–10.

Relative to the carbon stock losses due to wildfire in native forests, the loss of carbon stocks due to wildfires in plantations is minor (0.01 per cent and 0.03 per cent of total catastrophic losses in 2001–06 and 2006–11, respectively). The low losses from this source are due to the small area of plantations relative to native forest, and may also be due to management of some plantations to limit exposure to the effects of wildfire.

Carbon stock losses – Re-classification to non-forest

Reclassification of forest to non-forest occurs when forest cover is lost (excepting temporary losses in forests which are managed on a harvesting and regrowth cycle, or in forests which degrade and regenerate in response to physiological drivers of growth). This re-classification occurs because forests are cleared for agriculture, urban development or mining.

Over the period 2001–10, re-classification of forest land to non-forest land resulted in a reported decrease of carbon stocks in forest lands of approximately 169 Mt C (Table A6.3).

The decline in human-induced forest clearing in 2001–05 and 2006–10 (Table A6.3) was one of the main reasons why Australia's forest changed from a net source to a net sink of carbon between 2001–05 and 2006–10.

The conversion of plantations to non-forest became an increasing issue towards the end of the decade. It is expected that data will be available on the effect of this activity on carbon stocks in Australia's plantation forests in the near future.

Net exchange with atmosphere and net effect of transfers and re-classification

The net change in Australia's forest carbon stocks was -91 Mt C in 2001–05, and +10 Mt C in 2006–10 (Table A6.3). This net change can be separated into the net exchange with the atmosphere (e.g. through tree growth and fire) and the net transfers in and out of the forest (e.g. through harvesting wood products) (Table A6.3). In the decade to 2010, net exchange with the atmosphere increased from a gain of 51 Mt C during 2001–05 to a gain of 127 Mt C during 2006–10 (Table A6.3). This was primarily due to a reduction in losses associated with fire and an increase in carbon stock gains associated with recovery from fire during 2006–10. Over this same period, there was a decrease in losses associated with carbon stock transfers and the re-classification of land, from 142 Mt C in 2001–05 to 117 Mt C in 2006–11. The key cause of this reduced rate of loss was a decline in losses from re-classification of land to non-forest (forest clearing).

Table A6.5: Stock of carbon in Australia's living forests, 2001-10

	2001-05 Mt C	2006-10 Mt C	2001-10 Mt C
Opening stock	12,922	12,831	12,922
Gains in stock			
Growth in stock			
Native forests	175	182	357
Plantations	27	32	59
Total	202	214	416
Reclassification to forest ¹			
Native forests	-	-	-
Plantations	8	5	12
Total	8	5	12
Total additions to stock	209	219	428
Losses from stock			
Transfer to product pools ²			
Native forests	35	31	66
Plantations	18	19	37
Total	53	50	103
Managed losses ³			
Native forests	58	32	90
Plantations	-	-	-
Total	58	32	90
Catastrophic losses			
Native forests	93	55	148
Plantations	0	0	0
Total	93	55	148
Reclassification to non-forest ⁴			
Native forests	97	72	169
Plantations	-	-	-
Total	97	72	169
Total reductions in stock	300	209	509
Closing stock	12,831	12,841	12,841
Net change	-91	10	-81
Net exchange with atmosphere ⁵	51	127	178
Net change from re-classification of land to and from forest and transfers to products ⁶	-142	-117	-259

1 Gain by sector of carbon in debris and soil associated with transfer of land into sector

2 Transfers to wood and wood products in service

3 Emissions from prescribed burns, post-harvest burns, and burning as part of forest clearing

4 Loss from sector of carbon in debris and soil associated with transfer out of sector of cleared forest land or land where forest cover has been lost through dieback or degradation

5 Sum of growth in stock, managed losses and catastrophic losses

6 Sum of reclassification to forest, transfer to product pools and reclassification to non-forest

A6.3 Summary of Responses to UNFCCC ERT Recommendations and Comments

Table A6.6(a): Summary of responses to UNFCCC ERT recommendations: energy and cross cutting

Sector	Report and paragraph reference	ERT Recommendation	Response	Implementation
Energy	ARR 2012 31	Review opportunities to incorporate NGERs data into the annual submission and ensure time-series consistency where NGERs data are used	Updated fugitive emissions from open cut coal mining to further incorporate measured emissions from mines reporting under NGER using facility-specific gas measurement approach.	Recalculation for open cut coal mine fugitive emissions as a result of the inclusion of NGER data is explained section 3.8.5 and 3.8.4 of the 2015 NIR submission (Vol 1).
1.A	ARR 2014 17	The recalculations could have been more comprehensively explained in the NIR. The ERT recommends that Australia include more detailed information about fuel reallocation and emission changes resulting from recalculations in the NIR to improve transparency.	Accepted	Explanations of recalculations are provided in the following sections of the 2015 NIR submission (Vol 1): 3.3.5, 3.4.5, 3.5.5, 3.6.5, and 3.7.5.
1.A	ARR 2014 20	The ERT noted that the reference approach tables for the years prior to 2012 have not been revised to describe these differences. In response to the question raised by the ERT during the current review, the Party explained that due to the significant work required to update the reference approach for all years back to 1990, Australia is implementing this recommendation in stages over the 2014 and subsequent annual submissions. The ERT welcomes the Party's progress and reiterates the recommendation made in the previous review report that the Party prepare and revise the reference approach tables for the years prior to 2012 and present them in the NIR with explanations.	Accepted	Australia continues to implement the recommendation by progressively revising the reference approach tables for previous years in stages.

Sector	Report and paragraph reference	ERT Recommendation	Response	Implementation
1.A	ARR 2014 21	Australia noted that it understands that BREE is also in consultation with the IEA to improve the consistency of data reporting, and anticipates an improvement in the reporting of Australia's coal production to the IEA in the future. The ERT welcomes this effort and recommends that the Party provide details of any relevant update on this collaboration in the NIR, as well as including a rationale for any differences observed between the CRF tables and the data reported to the IEA to improve transparency.	Accepted	An update has been provided in section 3.2.6 of the 2015 NIR submission (Vol 1).
1.A Bunker fuels	ARR 2014 22	The ERT noted that the relevant information for jet kerosene in international aviation has not been provided in section 3.2.6 of NIR 2014. The ERT recommends that the Party continue to investigate the underlying issue and include a more detailed explanation in the text of its NIR.	Accepted	An update on the underlying issue (differences between data on jet kerosene in international aviation reported by Australia in the CRF tables and data published by the IEA) has been provided in section 3.2.6 of the 2015 NIR submission (Vol 1).
1.A Bunker fuels	ARR 2014 23	Data in the CRF tables on residual fuel oil consumption in international marine bunkers averages 4.4 per cent lower than data reported to the IEA since 2003. the ERT's view that Australia has started to implement the recommendation made in the previous review report to investigate the underlying issues leading to inconsistencies between the CRF tables and data reported to the IEA regarding residual fuel oil consumption in international marine bunkers. The ERT commends Australia for these activities and recommends that the Party reflect any progress made on this matter in the NIR.	Accepted	An update on the underlying issue (differences between data on fuel oil consumption in international marine bunkers reported by Australia in the CRF tables and data published by the IEA) has been provided in section 3.2.6 of the 2015 NIR submission (Vol 1).
1A Stationary combustion: liquid and solid fuels	ARR 2014 25	The ERT recommends that the Party include initial AD information from the seven national petroleum refining operations in the annual submission as an additional level of QA and to improve transparency.	Accepted	A table of national AD for petroleum refining has been provided in table A6.4 of the 2015 NIR submission (Vol 3).

Sector	Report and paragraph reference	ERT Recommendation	Response	Implementation
1A Stationary combustion: liquid and solid fuels	ARR 2014 26	In the NIR, for liquid fuel consumption in petroleum refining, Australia reported that emissions from refinery coke have also been noted in refining/storage (fugitive emissions from oil, natural gas and other sources). Australia decided several years ago to report emissions from refinery coke under fuel combustion as most other Parties also use this approach. The ERT agrees with Australia's approach, but recommends that the Party more clearly present in the NIR details of where these emissions are reported.	Accepted	A statement has been included in section 1.A.1.b (Petroleum refining) of the 2015 NIR submission (Vol 1) clarifying where refining coke emissions are reported.
1A Stationary combustion: liquid and solid fuels	ARR 2014 27	Australia has implemented the recommendation made in previous review reports to reallocate black coal from iron and steel production (energy sector) to metal production (industrial processes sector). There is also some minor use of black coal for combustion purposes, which has been retained in this category of the energy sector. This coal is driving the CO ₂ IEF to be higher than that of coke oven gas alone, as well as the annual fluctuations observed in the IEF. The ERT welcomes the Party's explanation and recommends that the Party include this information in the NIR to improve transparency.	Accepted	The information has been included section 3.4.3 of the 2015 NIR submission (Vol 1).
1A Stationary combustion: liquid and solid fuels	ARR 2014 28	There are significant inter-annual changes in CO ₂ emissions between 2010 (521.73 Gg) and 2011 (655.33 Gg) for combustion of liquid fuels in other stationary combustion. Australia explained that the CO ₂ emissions reflect the consumption of lubricants reported in the Australian Energy Statistics. The ERT recommends that Australia present this information in the NIR for transparency.	Accepted	Lubricants are now reported under the Industrial Processes and Product Use sector, in section 4.6 of the 2015 NIR submission (Vol 1), in accordance with IPCC 2006.

Sector	Report and paragraph reference	ERT Recommendation	Response	Implementation
1A3 Road transportation: liquid fuels – CH4	ARR 2014 29	For gasoline, the CH4 IEF from road transport varies throughout the time series, and in the reporting year 2012 is three times lower than in the base year 1990 (10.94 kg/TJ and 35.16 kg/TJ, respectively). In response to a question raised by the ERT during the review, Australia explained that, throughout the time series, progressively stricter emission standards have been introduced for new motor vehicles sold in Australia. The ERT welcomes the Party's explanation and recommends that the Party include this information in the relevant chapter in its NIR to improve transparency	Accepted	Discussion of the progressive application of stricter emissions standards for new motor vehicles in the Australian Design Rules is included in section 3.5.2 of the 2015 NIR submission (Vol 1).
1B1 Oil and natural gas: liquid and gaseous fuels – CO2 and CH4	ARR 2014 31	Australia has reported in CRF table 1.B.2 large inter-annual changes in CH4 emissions from natural gas production and processing. The ERT recommends that Australia increase the transparency of its discussion on the reasons underlying the observed trends, along with supporting data, in the relevant chapter in its NIR to improve accuracy and transparency.	Accepted	An explanation has been included in section 3.9.3 of the 2015 NIR submission (Vol 1).
1B1 Oil and natural gas: Flaring	ARR 2014 32	Australia is unable to separately report AD for flaring between oil and gas prior to 2009 and, therefore, flaring emissions were reported in the oil/gas combined category. The ERT recommends that the Party identify appropriate methods to ensure a consistent time series for this category, and present this information in the NIR to improve accuracy and transparency.	Accepted	Consideration will be given in future inventory submissions as to how the historical time series for oil and gas combined flaring may be split to create a time series consistent with the years 2009 onwards.
1B1 Oil: Petroleum storage	ARR 2014 32	The ERT noted that for fugitive emissions from petroleum storage the CO2 and CH4 IEFs slightly vary in the period 1990–2008 and decline thereafter. The ERT commends the Party for its efforts in responding to the request and investigating the issue, and recommends that Australia update the AD in the CRF tables, as planned.	Accepted	Further investigation will be undertaken into the activity data, and subsequent affect on the IEFs, for fugitive emissions from petroleum refining/storage. An explanation has been included in the NIR Vol 1 in section 3.9.6

Table A6.6(b): Summary of responses to UNFCCC ERT recommendations: Industrial processes

Sector	Report ref	ERT Recommendation	Response	Implementation
2B	ARR 2011 63	Although Australia has taken some steps to increase the transparency of its estimates of emissions from this category, aggregation of emissions continues to impede transparency. In the NIR, Australia notes that it plans to explore ways of disaggregating ammonia data while still protecting other confidential chemical industry data aggregated with ammonia. In response to a question raised by the ERT, Australia further noted that it had commissioned an independent review by CSIRO of the handling of confidential data in the inventory. The ERT strongly recommends that Australia continue to increase the transparency of the chemical industry inventory by disaggregating data further.	Australia will continue to explore options for increasing the transparency of IP emissions estimates while remaining sensitive to the confidentiality requirements of NGER data.	To be implemented in future submissions subject to data confidentiality constraints.
2F	ARR 2011 73	One area where Australia could further improve the transparency of its inventory is regarding the treatment of sealed-pressure electrical equipment in its NGERs programme and inventory. Because sealed-pressure equipment is rarely serviced during its lifetime, the mass balance methods used by utilities reporting under Australia's NGERs programme will not capture emissions from this source. Instead, the 2006 IPCC Guidelines recommend that appropriate EFs be applied to the data for the total nameplate capacity of sealed-pressure equipment reported in the country. The ERT, therefore, encourages Australia to more clearly discuss the fraction of reported nameplate capacity that consists of sealed-pressure equipment and the methods that Australia uses to estimate emissions from this equipment. The ERT notes that reporting by equipment importers, which Australia indicated could occur under proposed legislation, could be quite helpful in developing or checking estimates of the nameplate capacity of sealed-pressure equipment.	Australia will review this area of the inventory and provide further information in future submissions pending the availability of suitable data.	To be implemented in future submissions subject to data availability.

Sector	Report ref	ERT Recommendation	Response	Implementation
2.B	ARR 2012 51	Provide the disaggregated data, or information on the improvement plan, to improve transparency in relation to the chemical industry	Australia remains committed to enhancing the transparency of the chemicals sector estimates and will continue to explore additional options within the confidentiality restrictions of the NGER	Confidentiality continues to be an issue in the chemicals sector where there are only a small number of companies in operation. The confidentiality provisions of the NGER Act under which chemical industry data are obtained are explicit and restrict publication of such confidential data. In recent years, Australia has invested effort in providing as much information as it can within the restrictions of the NGER Act, including provision of implied emission factor information and discussions of comparisons with other Annex 1 parties Act.
2.F	ARR 2012 55 ARR 2013 Draft	Disaggregate the emissions from electrical equipment and report them separately under each function (operation and disposal)	Reject	Australia does not currently have access to data that would make this disaggregation possible. As set out in the NIR, the emission factors obtained under NGERS have been derived from gas mass balances and integrate operational and disposal phases of the equipment life-cycle. Any effort to disaggregate emissions estimates currently would be based on an assumption and would likely result in inaccurate allocation between the operation and disposal.
2F Consumption of halocarbons and SF ₆ – HFCs	ARR 2014 38	The NIR does not contain a clear description of AD sources, EFs and methodology. The ERT reiterates the recommendation made in previous reports that the Party continue to increase the transparency for this category by providing a clear description of AD, EFs and the methodology used for estimating emissions.	Australia provides a detailed description of AD sources, EFs and methodology in NIR section 4.8.2	See section 4.8.2 of the NIR

Sector	Report ref	ERT Recommendation	Response	Implementation
2F Electrical equipment – SF6	ARR 2014 39	Although the ERT is comfortable that Australia's approach, – AD and EF are sufficiently robust and that total emissions are accurately reported, the ERT nevertheless reiterates the recommendation made in the previous review reports that Australia improve the transparency of its reporting by disaggregating the emissions and reporting the estimates separately under each function (operation and disposal).	Data do not currently exist to enable the disaggregation of disposal and annual loss emissions as discussed in NIR section 4.8.2.	See section 4.8.2 of the NIR

Table A6.6(c): Summary of responses to UNFCCC ERT recommendations: Agriculture

Sector	Report ref	ERT Recommendation	Response	Implementation
4	ARR 2009 91, 94, 95 ARR 2011 79 ARR 2013 67/70	<p>The ERT noted that many of the studies are relatively old (over 10 years). The ERT strongly recommends that Australia explain in its next annual submission how it plans to update such studies.</p> <p>Regarding research on Tropical EF: The ERT commends the efforts made by Australia and recommends that the Party provide an update of the results in the next annual submission</p> <p>Australia provided its improvement plan indicating that the in-country peer review of tier 2 parameters for enteric fermentation is in progress. The ERT encourages Australia to finalize these studies and to apply the results for the preparation of the inventory as soon as the study has been finalized</p>	<p>Implemented.</p> <p>New enteric fermentation relationship for pasture based cattle has been developed from Australian measurement data.</p> <p>New fertiliser N2O EFs have been developed from Australian measurement data</p>	See sections 5.3 and 5.6

Sector	Report ref	ERT Recommendation	Response	Implementation
4B	ARR 2008 45 ARR 2009 69,71 ARR 2010 100 ARR 2011 82 ARR 2012 64 ARR 2013 74 ARR2014 42	Australia calculated N ₂ O emissions from dairy cattle, with protein intake from dairy calves not included due to the early removal of calves from the herd. In response to a question raised by the ERT during the course of the review, Australia indicated that it intends to review the age at which calves are removed from the herd for its next annual inventory submission. The 2009-2014 ERTs reiterated the recommendation made during the previous reviews that Australia implement changes or report on progress made.	Implemented. A pre-weaning period has been implemented for dairy calves reflecting the different CH ₄ and N ₂ O emissions for these animals which are placed on milk, milk replacements and supplements until weaning.	See section 5.3.2.1 and 5.4.2.8
4B	ARR 2014 44	The ERT recommends that Australia implement the upgraded PigBal model into the Australian inventory as soon as it has undergone appropriate QA/QC controls.	Implemented	See Appendix 5.E
4C	ARR 2014 50	In response to a question raised by the ERT during the review on time series consistency for rice cultivation (section 6.4.3 of the NIR), the Party explained that the time series were ensured by using the same method and data sources in all years. The ERT welcomes this explanation and recommends that the Party include this explanation in the NIR to improve the transparency of its reporting.	Implemented	See section 5.5.3
4D	ARR 2014 45	During the previous review, the ERT noted that Australia had not transparently described the application of synthetic fertilizers to forests by disaggregating the quantity of fertilizer nitrogen (N) applied to forests from total fertilizer sales. The ERT reiterates the recommendation made in the previous review report that Australia include a full explanation in its NIR, and encourages the Party to continue to explore opportunities to collect these data.	Implemented	See section 5.6.2.1

Sector	Report ref	ERT Recommendation	Response	Implementation
4E	ARR 2014 48	In CRF table 4.A, Australia now uses the phrase “pasture” for camels and llamas and horses where 0.00 was previously used. However, this is not solved in CRF table 4.E where zeroes are still reported under additional information. The ERT reiterates the recommendation made in the previous review report that Australia use the appropriate values or notation keys.	Accept	Notation key NA used in additional information CRF tables where data is not relevant to the methods applied

Table A6.6(d): Summary of responses to UNFCCC ERT recommendations: WASTE

Sector	Report ref	ERT Recommendation	Response	Implementation
6A	ARR 2011 107	In the previous annual review report, Australia was encouraged to develop country-specific DOC and k values. As indicated in paragraph 107 above in its 2011 annual submission Australia still uses default values for DOC and k. The ERT reiterates the encouragement of the previous review report to adopt country-specific values for these parameters, but notes that this matter will be addressed in Australia's plan to use facility-specific parameter values from the NGER (2009-2012) system in future annual submissions.	To date, no facility-level decay rate constant information has been available under the NGER (2009-2013) system. Australia will continue to monitor NGER landfill data and make use of it as appropriate.	See section 7.10.1 of the NIR.
6C	ARR 2011 120 ARR 2014 77	<p>However, the CRF tables incorrectly report N₂O and CH₄ emissions from the incineration of waste (clinical waste and solvents) as "NA". Since these emissions are likely occurring, the ERT recommends that Australia quantify the emissions of N₂O from this category. If no data on EFs are available, the ERT recommends that Australia report those emissions as "NE", rather than "NA".</p> <p>The ERT also recommends that, for CO₂, CH₄ and N₂O emissions from MSW incineration, the Party replace the notation key "NA" with "NO" for the years since 1996. The ERT further recommends that this information is clearly documented in its NIR.</p>	<p>No EFs are provided for N₂O from the incineration of clinical waste or solvents in GPG. IPCC 2006 do include emission factors for sludge and industrial waste. Australia will review these factors to determine whether they are appropriate for application in clinical waste and solvent incineration.</p> <p>Accept – the appropriate notation key will be used in the CRF tables. NIR section 7.5 explains that municipal waste incinerators ceased operations after 1996.</p>	<p>An update will be provided in future inventory submissions.</p> <p>See NIR section 7.5</p>

Table A6.6(e): Summary of responses to UNFCCC ERT recommendations: Land Use Land Use Change and Forestry

Sector	Report ref	ERT Recommendation	Response	Implementation
LULUCF	ARR 2011 92	<p>Australia chose 50 years as the transition period for land-use conversion but this was not fully applied in its disaggregation of land uses into the land-use remaining and land-use conversion subcategories, which is inconsistent with the IPCC good practice guidance for LULUCF.</p> <p>The ERT recommends that Australia implement this planned improvement in its next annual submission, as it is needed so that the report is consistent with the IPCC good practice guidance for LULUCF.</p>	Accept	<p>Australia is currently reviewing the most appropriate length of conversion period for its national circumstances.</p> <p>1.1 The implementation of an extended dataset on land use change to 1940 would lead to higher emissions estimates for Forest Conversion for the entire time series, with larger impacts at the start of the time series, 1990, than for later periods of the time series (see Appendix 6.A). This step has not yet been implemented in the estimates presented in section 6.1. A related question, that of the appropriate length of the transition process, remains open. While the Department of the Environment assumes a 50 year period for the reporting of land in a land use change category, the IPCC assumes a default length of transition to a new carbon stock level of 20 years.</p>
LULUCF	ARR 2011 93	<p>Australia has elected to move lands from the conversion subcategory to the remaining category after 50 years but also use subcategories to separate recent land conversions from older land conversions.</p> <p>As Australia's current reporting is not consistent with the IPCC good practice guidance for LULUCF, which requires that any change in area of forest land should correspond to a change in land use, the ERT reiterates the recommendation of the previous review report that Australia apply this method consistently in its next annual submission.</p>	Accept	<p>Resolved in the 2015 inventory submission.</p> <p>A system to monitor for permanent changes in forest cover has been implemented. Area changes in the "other native forest" classification now only occur in response to permanent gain or losses of forest cover in response to land use change. See section 6.3.1 of the NIR.</p>

Sector	Report ref	ERT Recommendation	Response	Implementation
LULUCF	ARR 2011 94	<p>As indicated in the previous review report, Australia explained that changes in forest area under the subdivision “other native forests” do not always correspond to real changes in land use.</p> <p>In its 2011 annual submission, Australia reports that it plans to implement a research project to improve the reporting on these changes in land use and that the project will take the recommendation from the previous review report into consideration. The ERT welcomes this action, reiterates the recommendation from the previous review report and looks forward to the results being reported in Australia’s next annual submission.</p>	Accept	<p>Resolved in the 2015 inventory submission.</p> <p>A system to monitor for permanent changes in forest cover has been implemented. Area changes in the “other native forest” classification now only occur in response to permanent gain or losses of forest cover in response to land use change. See section 6.3.1 of the NIR.</p>
LULUCF	Para 95	<p>Australia assumes that there is no change in the soil carbon stock in the category forest land remaining forest land, which is estimated following the tier 1 approach of the IPCC good practice guidance for LULUCF. Australia reports that research is ongoing to implement higher tier modelling of soil carbon in all forest land remaining forest land subcategories. The ERT welcomes these activities and looks forward to the results of higher-tier modelling being implemented and reported in its next annual submission.</p>	Implement	<p>Australia’s progress to move to higher tier modelling of Forest land remaining Forest land has been slower than planned.</p> <p>Australia plans to implement spatial modelling of Forest land remaining Forest land for future inventory submissions.</p>
LULUCF	ARR 2013 draft	<p>Considering the complexity of the Australian land representation, the ERT recommends to add, in the main section, a summary table where, for each land category and subdivision, more relevant information related to land representation as the approach used, the background data and the transition period applied, is reported.</p>	Accept	<p>Additional information and supporting material on land classification and methods has been included with the 2015 submission. See section 6.2 and 6.2 and Appendix 6.A</p>

Sector	Report ref	ERT Recommendation	Response	Implementation
LULUCF	ARR 2013 draft	To enhance comparability of the GHGI and its consistency with IPCC categories it is recommended to allocate CO ₂ emissions from liming to CRF table 5(IV). Whether data available do not allow to disaggregate liming among land use categories, it is suggested to follow the common practice to assign all the activity data to the most relevant land use category (usually cropland) whilst assigning the notation key IE to other land uses.	Accept	No longer applicable to the LULUCF sector.
LULUCF	ARR 2013 draft	Considering that the Tier 1 methodology for SOM in cropland and grassland is based on changes in management practices (i.e. to any change in management practices a C stock change is associated; and only changes in management practices determine to count for changes in C stock	Accept	See Volume 2, 6.8.5, Planned Improvements.
LULUCF	ARR 2014	The ERT recommends that Australia include in the NIR information regarding the estimation model, specifically regarding the change concerning shedding and resprouting and also recommends that the Party further monitor the performance of the revised model and provide updates in the NIR. Finally, the ERT recommends that the Party provide detailed explanations on any future recalculations in the NIR.	Accept	Australia has made further revisions to the <i>forest land remaining forest land</i> sub-classification other native forests in the 2015 inventory submission. These changes, and the recalculations due to these changes, are explained in section 6.4.
LULUCF	ARR 2014	The ERT recommends that the Party include this more detailed information regarding the combination and harmonization of different data sources/ databases to represent land-use categories and conversions, as well as the time frames used for these conversions and the associated changes to soil carbon stocks in the annual submission.	Accept	Section 6.3 and appendix 6.A of the NIR have been updated with the 2015 inventory submission.

Sector	Report ref	ERT Recommendation	Response	Implementation
LULUCF	ARR 2014	The ERT recommends that the Party include, in the LULUCF chapter, synthesized information related to land representation, including the methodology applied for the assessment of land use and land-use change, background data and transition periods applied, in line with the information provided during this review.	Accept	Section 6.3 and appendix 6.A of the NIR have been updated with the 2015 inventory submission.
LULUCF	ARR 2014	The ERT reiterates the recommendation made in the previous review report that the Party include, in the NIR, a confusion matrix for both land converted to grassland and land converted to cropland.	Accept	A confusion matrix is included in Appendix 6.A of the NIR
LULUCF	ARR 2014	The ERT recommends that the Party enhance QA/QC measures and ensure full correspondence between data reported in the NIR and the CRF tables regarding distribution on total land area per land-use categories/subcategories.	Accept	These issues have been corrected in the 2015 inventory submission.
LULUCF	ARR 2014	The ERT recommends that the Party present in the NIR more comprehensive information regarding wood harvesting, in line with the explanations provided during the review.	Accept	The data source for wood harvesting activity data has been updated for the 2015 inventory submission. This updated activity data is explained in section 6.4.1.
LULUCF	ARR 2014	The ERT recommends that the Party include in the NIR additional information regarding the mapping of plantations established/recorded from 1940–1989, and the associated estimates.	Accept	The Department has a project underway to develop a map of the location of plantations established before 1990. It is hoped that this project can be finalised over the coming 12 months.
LULUCF	ARR 2014	The ERT recommends that, in order to increase transparency, the Party present in the NIR the methodology used to estimate emissions from fuelwood extractions from dead organic matter pools.	Accept	The description of the method used to estimate emissions from fuelwood consumption has been updated in the NIR. See section 6.5.4.

Sector	Report ref	ERT Recommendation	Response	Implementation
LULUCF	ARR 2014	Since the notion of "NFI" can have different meanings among the reporting Parties, the ERT recommends that Australia provide in the NIR additional information regarding the mandate of its NFI, detailing the alternative means used to obtain and derive data on emissions and removals from the biomass and non-biomass pools in the forest land remaining forest land subcategory.	Accept	<p>Australia applies the tier 3 FullCAM model to estimate emissions and removals associated with native forest harvesting in the forest land remaining forest land classification. For these harvested forests, the activity data is derived from the Australian Forest and Wood Production Statistics (AFWPS) which is published by ABARES.</p> <p>As explained on the ABARES website: ABARES publishes comprehensive datasets relating to Australia's forestry sector in its biannual Australian Forest and Wood Products Statistics report, including time series of data on forest and wood products resources, production, consumption, trade and employment.</p> <p>http://www.agriculture.gov.au/abares/forestsaustralia/australian-forest-and-wood-products-statistics</p>
LULUCF	ARR 2014	The ERT noted that Australia reported "NE" for non-CO ₂ emissions from drainage of soils on forest land and used the notation key "IE" in table 11.2 in the NIR regarding drainage of soils under forest management. In response to a question raised by the ERT during the review, Australia acknowledged the error in NIR table 11.2 and committed to rectify it in the next annual submission. The ERT recommends that the Party enhance QA/QC activities and provide the corrected data.	Accept	Table 11.2 has been corrected in the 2015 inventory submission.

Sector	Report ref	ERT Recommendation	Response	Implementation
LULUCF	ARR 2014	Recommendations made in the previous review report included that Australia enhance its model by including the impact of management practices, and their changes, on the carbon stock changes in soil organic matter. The current ERT requested the Party to provide the estimates of carbon stock changes for the soils pool, by incorporating the impact of management practices. In response to the question raised by the ERT during the current review, Australia indicated that this is already included in its improvement plan and it is currently working to implement the new data on management practices, crop yields and soil carbon stocks into a tier 3 method, with a view to submitting significantly improved estimates in the 2015 annual submission. The ERT welcomes the ongoing efforts made by the Party to provide estimates that incorporate the effect of management practices and reiterates the recommendation made in the previous review report that the Party provide soil carbon estimates taking into account the changes to management practices.	Implemented	<p>These improvements have been included in the 2015 inventory submission.</p> <p>Details on data and sources for changes in management practices are provided in Appendices 6.B.4, 6.B.5 and 6.E.4</p> <p>The description of how the estimates of carbon stock changes for the soils pool, incorporating the impact of management practices are described in Sections 6.8.1 and 6.9.1</p>
LULUCF	ARR 2014	The ERT recommends that the Party enhance its QA/QC activities to ensure the appropriate use of notation keys and full consistency between the data in the CRF tables and the NIR. The ERT also recommends that the Party separately report perennial woody crops in the CRF tables.	Accept	These issues have been corrected in the 2015 inventory submission.
LULUCF	ARR 2014	The ERT recommends that Australia enhance its QA/QC activities to ensure the appropriate use of notation keys and full consistency between the data in the CRF tables and the NIR. The ERT also recommends that the Party separately report perennial woody biomass in the CRF tables.	Accept	These issues have been corrected in the 2015 inventory submission.

Sector	Report ref	ERT Recommendation	Response	Implementation
LULUCF	ARR 2014	Party responded that the time series for soil carbon has been recalculated following the implementation of a dynamic crop/pasture growth module in FullCAM, following the recommendation made in the 2012 annual review report. The ERT recommends that the Party further report in the NIR the changes made to FullCAM, as well as on the progress made regarding the relevant, ongoing work referred to in paragraph 62 above.	Implemented	<p>These improvements have been included in the 2015 inventory submission.</p> <p>Details on data and sources for changes made to FullCAM are provided in Appendices 6.B.4 6.B.5, 6E.1 and 6.E.4.</p> <p>The description of how the estimates of carbon stock changes for the soils pool, are described in Sections 6.8.1 and 6.9.1</p>
LULUCF	ARR 2014	The ERT recommends that the Party identify in the annual submission the conversions from forest land to wetlands, and provide separate AD and emission estimates.	Accept	Australia has commenced a project to enable the disaggregation of forest land converted to wetlands its emissions estimates of forest conversion.
LULUCF	ARR 2014	The ERT recommends that the Party distinguish in the annual submission the conversions from forest land to settlements, and provide separate AD and emission estimates.	Accept	Australia has commenced a project to enable the disaggregation of forest land converted to wetlands its emissions estimates of forest conversion.
LULUCF	ARR 2014	The ERT noted that Australia reports "IE" for AD in CRF table 5(V) for grassland remaining grassland, without an indication of where the AD are reported. In response to a question raised by the ERT during the review, the Party stated that AD for this land-use category have been omitted from this table, but indicates that these data will be included in the next annual submission. ERT recommends that the Party include these data, enhancing the completeness of the reporting.	Accept	This issue has been corrected in the 2015 inventory submission.
LULUCF	ARR 2013 Draft	<p>The model does not reconcile data on C stock growth, which it simulates, in any X area of forest plantation and data on harvested stock data that come from the statistics of forest plantations. This to ensure that the model does not over-under estimate, systematically, the carbon accumulation associated with forest growth and, consequently the carbon loss associated with harvesting at the end of the cultural cycle</p> <p>The ERT recommends to implement such verification exercise in next inventory.</p>	Accept	Further documentation of this verification was included in Volume 2 of the NIR.

Table A6.6(f): Summary of responses to UNFCCC ERT recommendations: ARTICLE 3.3 ACTIVITIES

Sector	Report ref	ERT Recommendation	Response	Implementation
KP Art. 3.3	ARR 2011 128	For the same reasons as for afforestation and reforestation activities, the land cover transitions in table 7.5 of the NIR do not match the deforestation areas for the activities under Article 3, paragraph 3, of the Kyoto Protocol. In the CRF table NIR-2 Australia reports the deforested areas for 2008 and 2009. During the review, Australia provided the ERT with a preliminary estimate of the annual area of land subject to deforestation under the Kyoto Protocol. To improve transparency the ERT encourages Australia to also present the annual deforested area since 1990 in the NIR of its next annual submission.	Accept	Consistent with the updated IPCC requirements, all land clearing since 1990 that is included in the forest land converted to cropland and grassland classifications under the Convention is also included in the KP-LULUCF inventory under Deforestation. See section 11.4.4 of the NIR.
	ARR 2012 111	Include forest land that “naturally” regrew after 1990, and that is subject to the implemented legal and regulatory framework that, in practice, results in human-induced afforestation and reforestation activities, in the reporting under Article 3, paragraph 3, of the Kyoto Protocol.	Accept	Forests which naturally regrew on land that was clear of forest on 31 December 1989 and is subject to an implemented legal and regulatory framework that, in practice, results in human-induced afforestation and reforestation activities, is included in the reporting under Article 3, paragraph 3, of the Kyoto Protocol. See section 11.5.1.2 of the NIR.
	ARR 2014	In response to the question raised by the ERT during the review, the Party acknowledged that the ‘other land’ was reported as zero by mistake and committed to correct the error in the next annual submission. The ERT recommends that the Party enhance its QA/QC measures for a fully consistent representation of land and provide the corrected figures.	Accept	This issue has been corrected in the 2015 inventory submission.
	ARR 2014	The ERT recommends that the Party closely consider its current national circumstances in the context of the new UNFCCC Annex I inventory reporting guidelines to ensure that all of the required land areas, emissions and removals are accurately accounted for in the annual submission, including emission estimates from deforestation on each and any cleared forest land since 1990, regardless of its land use on 31 December 1989.	Accept	Emission estimates are included in Australia’s inventory for all lands subject to an activity under the Kyoto Protocol since 1990.

ANNEX 7: Description of Australia's National Registry

The description of Australia's national registry follows the reporting guidance set down in decision 15/CMP.1, part II (Reporting of supplementary information under Article 7, paragraph 1, E. National registries) under the KP.

A7.1 Name and contact information of the registry administrator designated by the Party to maintain the national registry

Shaun Calvert
Registry Administrator
Clean Energy Regulator
GPO Box 621
CANBERRA ACT 2601
Tel: +61 2 6159 3398
Email: shaun.calvert@cleanenergyregulator.gov.au

A7.2 Names of any other party with which the party cooperates by maintaining their respective registries in a consolidated system

The ANREU is not operated in a consolidated system with any other Party's registry.

A7.3 A description of the database structure and capacity of the national registry

The following is an extract from the Software Specifications for the ANREU.

Front end server

The ANREU runs Microsoft Internet Information Services 7 (IIS) for its front-end web server. All incoming requests will enter and outgoing responses will exit through the IIS server. The IIS server rewrites URLs, then either passing it to the application server or back to the client. SSL termination happens on this tier. Secure Socket Layer (SSL) provides a secure connection between the ANREU and a client's web browser or the ITL. SSL uses a certificate which has been issued by a security authority to encrypt data moving over the unsecured internet. Beyond this point data will travel unencrypted between this front-end server and the application server. This is considered internal to the application. The IIS server converts all inbound and outbound HTTP communication to HTTPS secure communications.

Requests from the ITL and responses from the ANREU follow the same pattern. However, the front end server is not used for outgoing connections to the ITL initiated by the ANREU.

Application server

The middle tier serves the ANREU web application and uses Apache Tomcat 7.0. Apache Tomcat is an open source implementation of the Java Servlet and JavaServer Pages specifications that originally started as Sun Microsystems' original reference implementation. Tomcat runs the compiled Java Bytecode and allows for external access to application. Tomcat also provides externalized configuration for the application such as database connection details.

For outgoing requests to the ITL initiated by the ANREU web application, SSL origination occurs in the ANREU web application itself. Encrypted responses from the ITL return directly to the web application.

Database

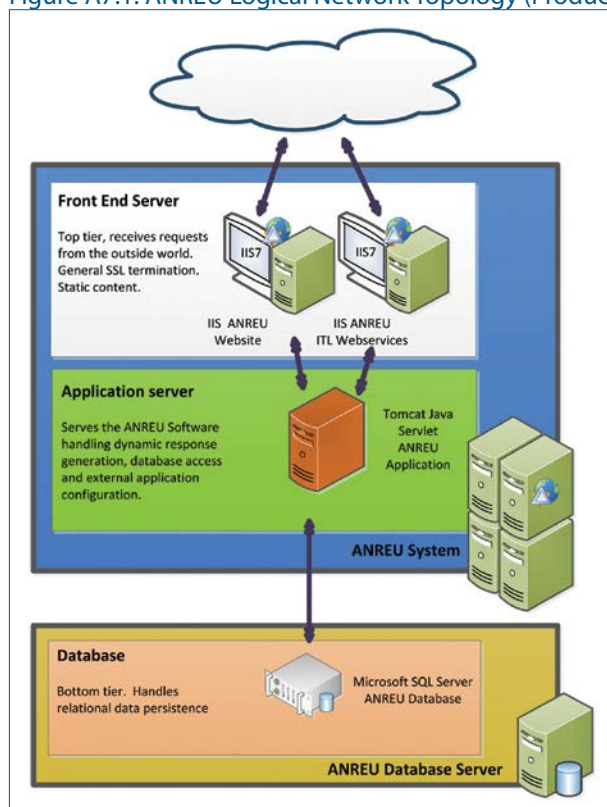
Microsoft SQL Server 2008 provides a relational database back-end for persistent storage of data for the application.

International Transaction Log Services

Transactions performed between the ANREU and the ITL take place through web service interfaces, following the Data Exchange Standards for Registry Systems under the Kyoto Protocol (DES). These web service interfaces are implemented using Apache Axis1 (Axis) which is an open source implementation of the Simple Object Access Protocol (SOAP). Axis supports generation of Java stub code based on the RPC/Encoded Web Service Definition Language (WSDL) specified by the DES. SOAP web services map to an internal service layer, isolating the web service code from the application code so that changes to the application can be made without affecting the ITL web service contract.

There are two web service interfaces that run, the client interface which allows the sending of messages to the ITL, and the server interface which allows the ANREU to receive messages from the ITL. Both of these interfaces are defined as WSDLs in the DES.

Figure A7.1: ANREU Logical Network Topology (Production Environment)



A7.4 A description of how the national registry conforms to the technical standards for the purpose of ensuring the accurate, transparent and efficient exchange of data between national registries, the clean development registry and the independent transaction log, including (i) to (vi) below

The ANREU contains the functionality to perform issuance, conversion, external transfer, (voluntary) cancellation, retirement and Reconciliation processes using XML messages and web-services as specified in the latest version of the Data Exchange Standards for Registry Systems under the Kyoto Protocol (DES).

In addition, the ANREU also contains: 24 Hour Clean-up, Transaction Status enquiry, Time Synchronisation, Data Logging requirements (including, Transaction Log, Reconciliation Log, Internal Audit Log and Message Archive) and the different identifier formats as specified in the UNFCCC DES document.

(i) A description of the formats used in the national registry for account numbers, serial numbers for ERUs, CERs, AAUs, and RMUs, including project identifiers and transaction numbers

The formats used in the ANREU are as specified in Data Exchange Standards for Registry Systems under the Kyoto Protocol (DES). Annex F – Definition of identifiers.

(ii) A list, and the electronic format, of the information transmitted electronically when transferring ERUs, CERs, AAUs, and/or RMUs to other registries

The formats used in the ANREU to transmit information to other registries are specified in the Data Exchange Standards for Registry Systems under the Kyoto Protocol (DES).

(iii) A list, and the electronic format, of the information transmitted electronically when acquiring ERUs, CERs, AAUs, and/or RMUs from other national registries or the CDM registry

The formats used in the ANREU to acknowledge the messages transmitted to other registries are specified in the Data Exchange Standards for Registry Systems under the Kyoto Protocol (DES).

(iv) A list, and the electronic format, of the information transmitted electronically from the national registry to the independent transaction log when issuing, transferring, acquiring, cancelling and retiring ERUs, CERs, AAUs, and/or RMUs

Information will be transmitted to the ITL in the message formats specified in the Data Exchange Standards for Registry Systems under the Kyoto Protocol (DES).

(v) An explanation of the procedures employed in the national registry to prevent discrepancies in the issuance, transfer, acquisition, cancellation and retirement of ERUs, CERs, AAUs, and/or RMUs

In order to minimise discrepancies between the ANREU and the ITL, the following approach has been adopted:

- Communications between the registry and the ITL are via web-services using XML messages – as specified in the Data Exchange Standards for Registry Systems under the Kyoto Protocol (DES). These web services, XML message format and the processing sequence are checked by the registry to ensure the compliance with the DES;
- The registry validates data entries against the formats of information as specified in Annex F of the DES;
- The registry implements internal controls in accordance with the checks performed by the ITL – as documented in Annex E of the DES.

- All units that are involved in a transaction are earmarked internally within the registry; thereby preventing the units from being involved in another transaction until a response has been received from the ITL and the current transaction has been completed;
- The web service that sends the message to the ITL for processing will ensure that a message received acknowledgement is received from the ITL before completing the submission of the message. Where no acknowledgement message has been received following a number of retries, the web-service would terminate the submission and roll back any changes made to the unit blocks that were involved;
- Where a 24 hour clean-up message is received from the ITL, the existing web service would roll back any pending transactions for the units that were involved, thereby preventing any discrepancies in the unit blocks between the registry and the ITL;
- Finally, if an unforeseen failure were to occur, the data discrepancies between our registry and the ITL can be corrected via a manual intervention function. Following this, reconciliation will be performed to validate that the data is in sync between the registry and the ITL. If a discrepancy reoccurs in the registry, the following measures will be applied:
 - Identification, and registration of the discrepancy;
 - Identification of the source of the discrepancy (DES, registry specifications, erroneous programming code);
 - Elaboration of a resolution plan and testing plan;
 - Correction and testing of the software;
 - Release and deployment of the corrected software.

(vi) An overview of the security measures employed in the national registry to deter unauthorised manipulations and minimize operator error

Below is a brief description of security measures implemented by the ANREU. For more detailed information, please refer to the formal readiness documentation which has been submitted as required to the ITL.

A7.5 Identification and Authentication

All applicants looking to open an account in the ANREU are required to provide specified proof of identity documentation, along with completing a “fit and proper” person test. These identity requirements are defined in the *Australian National Registry of Emissions Unit Act 2011* and the *Australian National Registry of Emissions Unit Regulations 2011*.

Access to the registry is allowed via a personal username and password – allocated as a part of a Registration process performed by the Clean Energy Regulator. Passwords have an expiry date and any reset requires revalidation of the user’s identity. Password configuration is as per Australian Government guidelines.

A7.6 Access control

Users of the ANREU are divided into four security groups. These groups control the access and security at the application level. A user’s login information is assigned to a user group, which determines what the user can and cannot do within the system.

The Registry supports the following user groups.

System Administrator

The System Administrator group has global authority throughout the Registry. This user is responsible not only for the day-to-day functionality of the system, but also for administrative support. This may include user management, managing and setting batch jobs, and reviewing audit and transaction logs

Account Administrator

This role is limited to selected users within the Clean Energy Regulator and allows access to account administration functions within the ANREU (creation/editing/deletion of account holders, accounts and users). An Account Administrator is unable to perform any transactions (e.g. unit transfers) in the ANREU.

Systems Auditor

A Systems Auditor has read only access to ANREU Account and Transaction information. A Systems Auditor is unable to update any information on an Account, nor is able to perform any transactions. Systems Auditor access is only available to personnel employed by the Clean Energy Regulator.

Industry User/Account Holders

Industry Users are external persons who require access to specific accounts within the ANREU. Users at this level are established when an ANREU account is initially created, and can be updated by the Account Holder. All Industry Users must pass required Proof of Identity and Fit and Proper person validations prior to being associated with an account. Additional security permissions are maintained for each Industry User associated with each account e.g. the ability to initiate or approve transactions for that account. These permissions are set by the Clean Energy Regulator upon advice from the account holder. A Read Only option is available, which requires management of the permissions – a read only Industry User would have access to view the holdings and transaction history of an account they are associated with, but is unable to initiate or approve any transactions for that account.

A7.7 Access protection

In order to prevent operator errors, the ANREU incorporates validations on all user inputs to ensure that only valid details are submitted for processing. The ANREU displays confirmation of user input to help the user to spot any errors that had been made and implements an internal approval process (input of relevant password details) for secondary approval for relevant operations before submitting the details to the ITL for processing.

Additional Security measures

In addition to the above, the ANREU incorporates an initiator / approver design to assist in mitigating the risks associated with high risk unit transfer functions. The initiator / approver function requires a transaction to be initiated by one identity (authorised representative) and be approved by another (authorised representative). The approval step includes validating the transaction by entering a single use PIN issued to the approver when the “initiate” transaction component is completed.

This measure supports the recommendations as outlined by the ITL Change Advisory Board.

A7.8 A list of the information publicly accessible through the user interface to the national registry

Non-confidential information has been made accessible to the public in line with the requirements of decision 13/CMP.1 annex II.E on the National Registry website under the Public Reports menu.

Up to date information on accounts as required by paragraph 45 has been included under Public Reports > Accounts. No ERUs have been issued to date so no information is available.

Information available to the public includes:

- Account name: the holder of the account;
- Account type: the type of account;
- Commitment period;

Information relating to projects as required by paragraph 46 has been included under [Public Reports > Joint Implementation Project Information Report](#).

Holding and transaction information as required by paragraph 47 is published as described below:

- (a) The total quantity of ERUs, CERs, AAUs and RMUs in each account at the beginning of the year is available under [Public Reports > Account Information Report, with Unit Block Holdings](#) for each account
- (b) The total quantity of AAUs issued on the basis of the assigned amount pursuant to Article 3, paragraphs 7 and 8 is available at [Public Reports > Annual Holding and Transaction Summary Report](#)
- (c) The total quantity of ERUs issued on the basis of Article 6 projects is available at [Public Reports > Annual Holding and Transaction Summary Report](#)
- (d) The total quantity of ERUs, CERs, AAUs, and RMUs acquired from other registries and the identity of the transferring accounts and registries is available at [Public Reports > Annual Holding and Transaction Summary Report](#).
- (e) The total quantity of RMUs issued on the basis of each activity under Article 3 paragraphs 3 and 4 is available at [Public Reports > Annual Holding and Transaction Summary Report](#)
- (f) The total quantity of ERUs, CERs, AAUs, and RMUs transferred to other registries and the identity of the acquiring accounts and registries is available at [Public Reports > Annual Holding and Transaction Summary Report](#).
- (g) The total quantity of ERUs, CERs, AAUs, and RMUs cancelled on the basis of activities under Article 3, paragraphs 3 and 4 is available at [Public Reports > Annual Holding and Transaction Summary Report](#).
- (h) The total quantity of ERUs, CERs, AAUs, and RMUs cancelled following determination by the Compliance Committee that the party is not in compliance with its commitment under Article 3, paragraph 1 is available at [Public Reports > Annual Holding and Transaction Summary Report](#).
- (i) The total quantity of other ERUs, CERs, AAUs and RMUs cancelled is available at [Public Reports > Annual Holding and Transaction Summary Report](#).
- (j) The total quantity of ERUs, CERs, AAUs and RMUs retired is available at [Public Reports > Annual Holding and Transaction Summary Report](#)
- (k) The total quantity of ERUs, CERs and AAUs carried over from the previous commitment period is available at [Public Reports > Annual Holding and Transaction Summary Report](#).
- (l) Current holdings of ERUs, CERs, AAUs and RMUs in each account.

A7.9 An explanation of how to access information through the user interface of the national registry

Access to the ANREU is available through the internet at <https://nationalregistry.cleanenergyregulator.gov.au/>

A7.10 Measures to safeguard, maintain and recover data in the event of a disaster

The servers (main and backup sites) that host the ANREU are in physically secure data centres fitted with secure access control systems. All data centres are fitted with smoke detection and automatic fire suppression systems. Anti-virus software upgrades are downloaded and installed autonomously on to the servers as soon as they are released.

A full backup of each database and an hourly transaction log backup during business hours take place every day with the back-up media being held at an offsite third party secure storage facility. The database content will also be replicated at a minimum of 30 minute intervals to a secondary data centre location when the clustering environment is implemented. This will serve as the hosting platform for Disaster Recovery.

In the event of a disaster a decision will be taken (between the Clean Energy Regulator and the IT contract supplier) to invoke disaster recovery. This will involve:

- Stopping all transactions to the main platform.
- Ensuring that the committed transactions are replicated to the DR site.
- Switching all external interaction with the main site over to the secondary location.

The IT contract supplier is committed to resuming the service for the Regulator operators within 8 hours of the decision being made.

A7.11 Results of previous test procedures

Comprehensive testing information has been submitted as part of the ITL readiness documentation in December 2013. Please refer to this documentation for details.

Australia's independent assessment reports are available from the UNFCCC website http://unfccc.int/kyoto_protocol/registry_systems/independent_assessment_reports/items/4061.php

ANNEX 8: Report to Facilitate the Calculation of Australia's Assigned Amount for the Second Commitment period of the Kyoto Protocol

A8.1 Introduction

The aim of this annex is to present Australia's initial estimates of the assigned amount and net base year emissions for the second commitment period (CP2) of the Kyoto Protocol (KP). Until such time as the Australian Government ratifies the Doha Amendment, this annex does not constitute its submission, to the secretariat of the United Nations Framework Convention on Climate Change (UNFCCC), of the report to facilitate the calculation of the assigned amount pursuant to Article 3, paragraphs 7bis, 8 and 8bis for CP2 under the KP.

The accompanying *National Inventory Report 2013* (the Report) provides a full time series of greenhouse gas emission and removal estimates for Australia for the period 1990 – 2013. This inventory has been used to estimate Australia's assigned amount and base year emissions and has been submitted for international expert review, subject to the caveat that the information will be used for compliance purposes only at such time as the Australian Government ratifies the Doha Amendment to the KP.

Should Australia submit updated inventory data, it will also update the base year and assigned amount estimates included in this annex prior to the expert review of the Australian Government's submission of the report to facilitate the calculation of the assigned amount for the CP2.

A8.2 Requirements of the report to facilitate the calculation of the assigned amount for the CP2

According to decision 2/CMP.8, if a Party had a target under the first commitment period of the KP, the report to facilitate the calculation of the assigned amount for the CP2 shall contain the following information:

- a) Complete inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol, recalculated in accordance with decision 4/CMP.7 for all years from 1990, to the most recent year available. If the report is submitted at the same time as the submission of the Party's annual greenhouse gas inventory, only one inventory submission should be provided and both reports should be submitted in conjunction;
- b) Identification of the selected base year for nitrogen trifluoride;
- c) The agreement under Article 4, where the Party has reached such an agreement to fulfil its commitments under Article 3 jointly with other Parties;
- d) Calculation of the assigned amount pursuant to Article 3, paragraphs 7bis, 8 and 8bis, on the basis of its inventory of anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol.
- e) Calculation of the commitment period reserve in accordance with decision 11/CMP.1 or any subsequent revision thereof related to the calculation of the commitment period reserve;

- f) Identification of the election of activities under Article 3, paragraph 4, of the KP for inclusion in accounting for the CP2, in addition to those activities under Article 3, paragraph 4, of the KP that were elected in the first commitment period, together with information on how the national system will identify land areas associated with all additional elected activities and how land that was accounted for under activities under Article 3, paragraphs 3 and 4, of the KP in the first commitment period continues to be accounted for in subsequent commitment periods;
- g) Identification of whether, for each activity under Article 3, paragraphs 3 and 4, accounting will occur annually or for the entire commitment period;
- h) The forest management reference level as inscribed in the appendix to the annex to decision 2/CMP.7, any technical corrections as contained in the inventory report for the first year of the CP2 and references to those sections in the Report where such information is reported;
- i) Information on how emissions from harvested wood products originating from forests prior to the start of the CP2 have been calculated in the reference level;
- j) An indication of whether there is an intention to apply the provisions to exclude emissions from natural disturbances for the accounting for *afforestation* and *reforestation* under Article 3, paragraph 3, of the KP and/or *forest management* under Article 3, paragraph 4, of the KP during the CP2, including:
 1. Country-specific information on the background level of emissions associated with annual natural disturbances that have been included in its forest management reference level;
 - ii. Information on how the background level(s) for *afforestation* and *reforestation* under Article 3, paragraph 3, of the KP and/or *forest management* under Article 3, paragraph 4, of the KP have been estimated, and information on how the expectation of net credits or net debits during the commitment period has been avoided, including information on how a margin is established, if a margin is needed;

The rules for the CP2 of the KP were not finalised as expected at the 2014 UNFCCC conference in Lima, Peru. Consistent with Australia's statement at that meeting on this issue, information is included in this annex in accordance with the draft decision prepared by Parties at SBSTA 41 (FCCC/SBSTA/2014/L.29).

a. Complete inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol, for all years from 1990

Australia's most recently completed inventory – the *National Inventory Report 2013* (the Report) – was submitted to the UNFCCC in conjunction with this annex and the associated Common Reporting Format Tables.

This inventory has been used to estimate Australia's assigned amount and base year emissions and has been submitted for international expert review. The information contained in the Report is to be used for KP compliance purposes only at such time as the Australian Government ratifies the Doha Amendment to the KP.

Should Australia submit updated inventory data, it will also update the base year and assigned amount estimates included in this annex prior to the expert review of the Australian Government's submission of the report to facilitate the calculation of the assigned amount for the CP2.

b. Base year for nitrogen trifluoride

Australia has decided to use 1990 as the base year for nitrogen trifluoride, consistent with the base year for all gases included in the Report.

c. Agreement under Article 4 of the Kyoto Protocol

Australia will not be a participant in any Article 4 agreements.

d. Calculation of Australia's Assigned Amount

Based on the data contained in the Report, Australia's assigned amount for the CP2 of the KP is estimated to be 4,490.3 Mt CO₂-e. Details of this calculation are provided in table A8.1.

Table A8.1: Determination of Australia's Assigned Amount

Sector	Gg CO ₂ -e
Energy	292,820.723
Industrial Processes and Product Use	26,108.523
Agriculture	88,569.095
Waste	20,793.151
Land use change ¹	135,814.319
Total base year emissions estimate	564,105.811
99.5% of base year estimate	561,285.282
Australia's Assigned Amount (8 times 99.5% of base year estimates)	4,490,282.256

1 In accordance with Article 3.7bis, and consistent with the calculation of the base for CP1, as *land use change and forestry* (all emissions by sources and removals by sinks under category 4 of the revised *Guidelines for the preparation of national communication by Parties included in Annex I to the Convention, Part 1: UNFCCC reporting guidelines on annual greenhouse gas inventories*) constituted a net source for Australia in 1990 (103,300.489 Gg CO₂-e), the emissions from land use change in 1990 are included in the emissions estimate for the base year for the purposes of calculating Australia's CP2 assigned amount.

i. Application of Article 3.7ter

Article 3.7ter requires the calculation of a threshold beyond which a cancellation of CP2 assigned amount units (AAUs) is undertaken equal to any positive difference between a Party's CP2 assigned amount and eight times its average annual emissions for 2008, 2009 and 2010.

Table A8.2: Calculation of the threshold for AAU cancellation under Article 3.7 ter

Calculation of the Threshold for AAU cancellation	
Emissions ^a – 2008	602,544.350
Emissions ^a – 2009	602,225.781
Emissions ^a – 2010	597,684.920
Average Emissions 2008 -2010	600,818.350
Threshold for AAU cancellation: Average Emissions 2008 to 2010 times eight	4,806,546.803
Comparison of Total Assigned Amount with threshold for AAU cancellation	
Total Assigned Amount ^b	4,490,282.256
Threshold for AAU Cancellation	4,806,546.803
Total Assigned amount minus Threshold for AAU cancellation	-316,264.547
AAUs to be cancelled	

a Calculated as emissions from *energy, industrial processes and product use, agriculture, deforestation and waste* consistent with the UNFCCC definition of emissions and Kyoto Protocol accounting under Article 3.7 which treats *deforestation* like the *energy, industrial processes and product use, waste and agriculture* sectors. Land activities that are treated differently to other sectors, for which RMUs are issued, are not included in these calculations.

b As per the calculation in table 1.

As determined from table A.8.1, Australia's CP2 assigned amount is estimated from net emissions from *land-use change, energy, industrial processes and product use, agriculture* and *waste* in the 1990 emissions base year. Emissions from *deforestation* are treated in the same way as those from *energy, industrial processes and product use, waste* and *agriculture* sectors in the accounting towards the CP2 target.

The same approach is used to calculate average annual emissions for 2008 – 2010 i.e. the calculation includes emissions from *deforestation*¹⁵ and the *energy, industrial processes and product use, waste* and *agriculture* sectors.

As indicated in table A8.2, the estimate of Australia's CP2 assigned amount is below the calculated threshold for AAU cancellation derived from the estimate of Australia's average annual emissions for 2008 to 2010. Therefore, cancellation of AAUs is not required in accordance with Article 3.7ter.

e. Calculation of the commitment period reserve

As indicated in table A8.3, the commitment period reserve for CP2 is calculated to be 4,041.3 Mt CO₂-e, calculated as 90% of the estimated CP2 assigned amount pursuant to decisions 11/CMP.1, 1/CMP.8 and 2/CMP.8 and draft decision FCCC/SBSTA/2014/L.29.

Table A8.3: Calculation of the commitment period reserve

	Calculation
90% of the Assigned Amount	4,041,254.030

f. Election of activities under Article 3.4 for accounting in the period 2013–2020

Australia accounted for the mandatory Article 3.3 activities *deforestation* and *afforestation/reforestation* in the first commitment period of the KP.

In the CP2, Australia will continue to account for *deforestation* and *afforestation/reforestation* as well as the Article 3.4 activity, *forest management*, which is mandatory for the CP2. In addition, Australia elects to account for the following voluntary activities under Article 3 paragraph 4:

- *Cropland management*;
- *Grazing land management*; and
- *Revegetation*.

Chapters 6 and 11 of this report describe how Australia's national system will identify land areas associated with all Article 3.3 and Article 3.4 activities and how land accounted for under Article 3.3 activities in the first commitment period continues to be accounted in the CP2.

g. Accounting for Article 3.3 and Article 3.4 activities

Australia will account for all Article 3.3 activities annually in the CP2, in a continuation of the approach selected for the first commitment period.

Australia will account for *forest management* and elected Article 3.4 activities at the end of the CP2.

¹⁵ Strictly speaking, *deforestation* is a subset of land use change since it includes emissions from events since 1990 only. If *land use change* emissions are substituted for *deforestation* emissions for 2008-10, the average emissions estimate multiplied by eight is 4,854,996.891 Mt CO₂-e.

Table A8.4: Accounting mode elected by Australia for Article 3.3 and Article 3.4 activities

Article	Activity	Accounting mode
Article 3.3	Deforestation	Annual
Article 3.3	Afforestation/reforestation	Annual
Article 3.4	Forest Management	End-of-commitment period
Article 3.4	Cropland Management	End-of-commitment period
Article 3.4	Grazing land Management	End-of-commitment period
Article 3.4	Revegetation	End-of-commitment period

h. Australia's forest management reference level and technical corrections

The forest management reference level inscribed in the appendix to the annex to decision 2/CMP.7 was 4.7 Mt CO₂-e per year for Australia.

There have been a number of methodological refinements since this reference level was submitted, which include changes to address subsequently agreed rules for implementing the natural disturbance provision and calculating emissions from harvested wood products (decisions 2/CMP.7, 2/CMP.8 and IPCC 2014) as well as refinements to other methodological elements used in the estimation of *forest management* emissions (IPCC 2014). As a result, a technical correction of 3.6 Mt CO₂-e has been applied to Australia's forest management reference level. Australia's adjusted forest management reference for the CP2 is 1.1 Mt CO₂-e per year.

The technical correction and methodological refinements are described in detail in section 11.6 of the Report.

i. The treatment of harvested wood products originating from forests prior to the start of the CP2

Australia's forest management reference level includes emissions from harvested wood products produced since 1940. Refer to sections 11.6.4, 11.10 and 4.6 of the Report for a full explanation of the treatment of harvested wood products in Australia's forest management reference level as well as the models and methodologies used to estimate carbon stock changes from harvested wood products.

j. Natural disturbances

Australia intends to apply the provision to exclude emissions from natural disturbances to accounting for *forest management* during the CP2.

As described in section 11.6 of the Report, Australia has calculated a background level and margin of wildfire natural disturbance emissions for *forest management* lands using the IPCC default method (see IPCC 2014, page 2.48-2.50). The background level and margin are presented in table A8.5.

Table A8.5: Components of Australia's background level and margin for wildfire natural disturbances

Components	
Calibration period	2000-2012
Method used	IPCC default
Background level	2.63 Mt CO ₂ -e
Margin	3.35 Mt CO ₂ -e
Background level plus margin	5.98 Mt CO ₂ -e
Number of excluded years	Four
Excluded years	2003, 2007, 2009, 2010

Australia intends to apply a background level of zero for all other natural disturbances. In this case, there is no expectation of net credits or debits being generated by these natural disturbances.

Section 11.6 of the Report provides a detailed explanation of the methodology used to calculate the background level and margin of wildfire natural disturbance emissions for *forest management* lands and how the methodology avoids the expectation of net credits or debits.

k. Information reported elsewhere

The following information is included in the locations of the Report specified below:

- forest threshold values (Chapter 6);
- a description of Australia's national system (Chapter 1);
- a description of Australia's national registry (Annex 7).

As reported in Australia's Initial Report¹⁶ for the first commitment period of the KP, 1990 is the base year chosen for hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride.

¹⁶ http://unfccc.int/files/national_reports/initial_reports_under_the_kyoto_protocol/application/pdf/kyoto_target_web.pdf

ANNEX 9: General Notes, Glossary and Abbreviations

A9.1 General Notes

Units

The units mainly used in this inventory are joules (J), grams (g), tonnes (t), metres (m) and litres (L), together with their multiples. Standard metric prefixes used in this inventory are:

kilo (k) = 10^3 (thousand)

mega (M) = 10^6 (million)

giga (G) = 10^9

tera (T) = 10^{12}

peta (P) = 10^{15}

Emissions are generally expressed in gigagrams (Gg) in the inventory tables, as called for under international guidelines, and in megatonnes (Mt) in the text of the inventory report:

gigagram (Gg) = 1,000 tonnes = 1 kilotonne (kt)

megatonne (Mt) = 1,000,000 tonnes = 1,000 Gg

Gases

CF ₄	perfluoromethane (a perfluorocarbon)
C ₂ F ₆	perfluoroethane (a perfluorocarbon)
CH ₄	methane
CO	carbon monoxide
CO ₂	carbon dioxide
HFCs	hydrofluorocarbons
NF ₃	nitrogen trifluoride
N ₂ O	nitrous oxide
NMVOC	non-methane volatile organic compounds
NO _x	oxides of nitrogen
PFCs	perfluorocarbons
SF ₆	sulphur hexafluoride
SO ₂	sulphur dioxide

Global Warming Potentials

$\text{CO}_2 = 1$	$\text{HFC-23} = 14,800$
$\text{CH}_4 = 25$	$\text{HFC-125} = 3,500$
$\text{N}_2\text{O} = 298$	$\text{HFC-134a} = 1,430$
$\text{CF}_4 = 7,390$	$\text{HFC-143a} = 4,470$
$\text{C}_2\text{F}_6 = 12,200$	$\text{SF}_6 = 17,700$

Conversion Factors

From element basis to molecular mass

$$\text{C} \quad \text{CO}_2: \times 44/12 = 3.67$$

$$\text{C} \quad \text{CH}_4: \times 16/12 = 1.33$$

$$\text{N} \quad \text{N}_2\text{O}: \times 44/28 = 1.57$$

From molecular mass to element basis

$$\text{CO}_2 \quad \text{C}: \times 12/44 = 0.27$$

$$\text{CH}_4 \quad \text{C}: \times 12/16 = 0.75$$

$$\text{N}_2\text{O} \quad \text{N}: \times 28/44 = 0.64$$

Indicators

In the tables, the following standard indicators are used:

NO (not occurring) when the activity or process does not occur in Australia

NA (not applicable) when the activity occurs in Australia but the nature of the process does not result in emissions or removals

NE (not estimated) where it is known that the activity occurs in Australia but there are no data or methodology available to derive an estimate of emissions

IE (included elsewhere) where emissions or removals are estimated but included elsewhere in the inventory

C (confidential) where reporting at a disaggregated level could lead to the disclosure of confidential information

A9.2 Glossary

Accounting quantity	The accounting quantity for the Kyoto Protocol <i>land use, land use change and forestry</i> activities represents RMU credits issued or assigned amount units (AAUs) cancelled for a given year of the commitment period. A net removal will result in the issuance of RMU credits while a net source will result in the deletion of AAUs.
Activity	A process that generates greenhouse gas emissions or uptake. In some sectors it refers to the level of production or manufacture for a given process or category.
Automotive Diesel Oil (ADO)	A middle distillate petroleum product used as a fuel in high-speed diesel engines. It is mostly consumed in the road and rail transport sectors and agriculture, mining and construction sectors.
Anaerobic	A process relying on bacteria that can live without oxygen.
Anthropogenic	Resulting from human activities. In the inventory, <i>anthropogenic emissions</i> are distinguished from <i>natural emissions</i> .
Bagasse	The fibrous residue of the sugar cane milling process which is used as a fuel in sugar mills.
Briquettes	A composition fuel manufactured from brown coal, which is crushed, dried and moulded under high pressure without the addition of binders.
Calibration	Model calibration is the estimation and adjustment of model parameters and constants to improve the agreement between model outputs and a data set. Calibration requires high quality data that represent the range of conditions under which the model is required to perform so as to avoid possible bias in emission estimates.
Clinker	An intermediate product from which cement is made.
Coke	The solid product obtained from the carbonisation of suitable types of coal at high temperature. It is low in moisture and volatile matter and is mainly used in the iron and steel industry as an energy source and chemical agent. Semi-coke or coke obtained by carbonisation at low temperatures is included in this category.
Dolomite	A naturally occurring mineral ($\text{CaCO}_3 \cdot \text{mg CO}_3$) which can be used to produce lime, iron and steel.
Emission Factor	The quantity of greenhouse gases emitted per unit of some specified activity.
Emission Intensity	The total emissions divided by the total energy content of the fuels or the total energy used in a sector. The overall emissions intensity of coal used in Australia, for example, is determined by the quantity and emission factors for each of the many types and grades of coal used.
Enteric Fermentation	The process in animals by which gases, including methane, are produced as a by-product of microbial fermentation associated with digestion of feed.
Feedlot	A confined yard area with watering and feeding facilities where livestock (mainly beef cattle) are completely handfed for the purpose of production. It does not include the feeding or penning of cattle for weaning, dipping or similar husbandry purposes or for drought or other emergency feeding, or at a slaughtering place or in recognised saleyards.
Feedstocks	Products derived from crude oil and destined for further processing in the refining industry, other than blending. Products include those imported for refinery intake and those returned from the petrochemical industry to the refining industry, such as naphtha.
Flaring	The process of combusting unwanted or excess gases and/or oil at a crude oil or gas production site, a gas processing plant or an oil refinery.
Forest	Parties are required to select single minimum values for land area, tree crown cover and tree height. Australia uses a criteria of 20% tree crown cover, 2 metre minimum tree height, and a minimum of 0.2 hectares in land area for inclusion. These minimum criteria are within the ranges outlined in the Marrakech Accords.

Fuel Oil	Covers all residual (heavy) fuel oils including those obtained by blending.
Fugitive Emissions	Generally deliberate but not fully controlled emissions that typically result from leaks, including those from pump seals, pipe flanges and valve stems. Fugitive emissions also include methane emitted from coal mine seams. During petroleum storage tank filling, venting loss of vapour is a fugitive emission.
Global Warming Potential (GWP)	Represents the relative warming effect of a unit mass of a gas compared with the same mass of CO ₂ over a specific period. Multiplying the actual amount of gas emitted by the GWP gives the CO ₂ -equivalent emissions.
Greenhouse Gases	Gases that contribute to global warming, including carbon dioxide (CO ₂), methane (CH ₄), nitrous oxide (N ₂ O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF ₆) and nitrogen trifluoride (NF ₃). In addition, the photochemically important gases – NMVOCs, oxides of nitrogen (NO _x) and carbon monoxide (CO) – are also considered. NMVOC, NO _x and CO are not direct greenhouse gases. However, they contribute indirectly to the greenhouse effect by influencing the rate at which ozone and other greenhouse gases are produced and destroyed in the atmosphere.
Hydrofluorocarbons (HFCs)	Used as substitutes for chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs).
Industrial Diesel Fuel (IDF)	A petroleum product primarily consumed in the rail and water transport sectors.
Initial Assigned Amount	Represents Australia's emissions target for the first commitment period of the Kyoto Protocol. The initial assigned amount for the first commitment period was calculated as 108% of the base year emissions and is established as 591.5 Mt CO ₂ -e a year for each year of the first commitment period 2008-2012. At such time as the government ratifies the Doha Amendment to the KP, Australia's assigned amount for the second commitment period will be calculated based on its target of 99.5% of base year emissions.
Intergovernmental Panel on Climate Change (IPCC)	The international body responsible for assessing the state of knowledge about climate change. The IPCC increases international awareness of climate change science and provides guidance to the international community on issues related to climate change response.
Key Category	The IPCC <i>Good Practice</i> report (IPCC 2000) introduces the concept of key categories for prioritising the inventory development process. A key category has a significant influence on a country's total inventory of direct greenhouse gases in terms of absolute level of emissions, the trend in emissions, or both. The tier 1 key category analysis identifies categories that contribute to 95% of the total emissions or 95% of the trend of the inventory in absolute terms. Tier 2 analysis identified categories that contribute to 90% of total uncertainty in the inventory.
Kyoto Protocol	The Kyoto Protocol to the convention on climate change was developed through the UNFCCC negotiating process. The protocol was negotiated in Kyoto, Japan, in 1997. It sets binding greenhouse gas emissions targets for UNFCCC developed country Parties that ratify the agreement. The first commitment period of the KP ran from 2008-2012. In 2012 Parties to the KP agreed to the Doha Amendment, establishing a second commitment period (CP2) to run from 2013 – 2020. The CP2 is yet to enter into force.
Liquefied Petroleum Gas (LPG)	A light hydrocarbon fraction of the paraffin series. It occurs naturally, associated with crude oil and natural gas in many oil and gas deposits, and is also produced in the course of petroleum refinery processes. LPG consists of propane (C ₃ H ₈) and butane (C ₄ H ₁₀), or a mixture of the two. In Australia, LPG as marketed contains more propane than butane.
Lubricants	Hydrocarbons that are rich in paraffin and not used as fuels. They are obtained by vacuum distillation of oil residues.
Military Transport	Includes all activity by military land vehicles, aircraft and ships.
Natural Gas	Consists primarily of methane (around 90%, with traces of other gaseous hydrocarbons, as well as nitrogen and carbon dioxide) occurring naturally in underground deposits. As a transport fuel it is generally used in compressed or liquefied form.

Navigation	All civilian (non-military) marine transport of passengers and freight. Domestic marine transport consists of coastal shipping (freight and cruises), interstate and urban ferry services, commercial fishing, and small pleasure craft movements. International shipping using marine bunker fuel purchased in Australia is reported but not included in the national inventory emissions total.
NMVOG	Non-methane volatile organic compounds such as alkanes, alkenes and alkynes, aromatic compounds and carbonyls that are gases at standard temperature and pressure (i.e. Boiling points below 200°C) and normally 10 or less carbon atoms per molecule; excludes chlorofluorocarbons (CFCs).
PFC	Perfluorocarbons, chemical compounds containing carbon and fluorine atoms only (e.g. CF ₄ and C ₂ F ₆).
Prescribed Burning	The intentional burning of forests to reduce the amount of combustible material present and thereby reduce the risk of wildfires. In Australia this is known as 'fuel reduction burning'.
Process Emission	The gas released as a result of chemical or physical transformation of materials from one form to another.
Reference approach	A 'top-down' tier 1 IPCC methodology for estimating CO ₂ emissions from fuel combustion activities (1.a).
Sink	Any process, mechanism, or activity that removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere.
Solid Waste	Waste from various activities; includes <i>municipal solid waste</i> (waste from domestic premises and council activities largely associated with servicing residential areas; such as street sweepings, street tree lopping, parks and gardens and litter bins), <i>commercial and industrial waste</i> , and <i>building and demolition waste</i> .
Solvent	An organic liquid used for cleaning or to dissolve materials.
Source	Any process or activity that releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere.
Tier	The IPCC methods for estimating emissions and removals are divided into 'tiers' encompassing different levels of activity and technology detail. Tier 1 methods are generally very simple (activity multiplied by default emissions factor) and require less data and expertise than the most complicated tier 3 methods. Tier 2 and 3 methods generally require more detailed country-specific information on things such as technology type or livestock characteristics. The concept of tiers is also used to describe different levels of key source analysis, uncertainty analysis, and quality assurance and quality control activities.
Town Gas	Includes all manufactured gases that are typically reticulated to consumers, including synthetic natural gas, reformed natural gas, tempered LPG, and tempered natural gas.
Uncertainty	Uncertainty is a parameter associated with the result of measurement that characterises the dispersion of values that could be reasonably attributed to the measured quantity (e.g. The sample variance or coefficient of variation). In general inventory terms, uncertainty refers to the lack of certainty (in inventory components) resulting from any causal factor such as unidentified sources and sinks, lack of transparency etc.
United Nations Framework Convention on Climate Change (UNFCCC)	An international environmental treaty which entered into force in 1994. Parties to the convention have agreed to work towards achieving the ultimate aim of stabilising 'greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'.
Validation	Model validation is a demonstration that a model, within its domain of applicability, possesses a satisfactory range of accuracy consistent with the intended application of the model. Validation compares simulated system output with real system observations using data not used in model development. It is used to test the model performance and that the calibration of the model has not produced biased emission estimates.

Verification	In terms of the inventory verification refers to the collection of activities and procedures that can be followed during the planning and development, or after completion of an inventory that can help establish its reliability for the intended application of that inventory. Typically methods external to the inventory are used to verify the truth of the inventory, including comparisons with estimates made by other bodies. Verification as it pertains to modelling is a demonstration that the modelling formalism is correct. It is a check that calculations, inputs, and computer code is correct.
Venting	The process of releasing gas into the atmosphere without combustion. This may be done either at the production site or at the refinery or stripping plants. It is done to dispose of non-commercial gas or to relieve system pressure.

A9.3 Abbreviations

AAA	Aerosol Association of Australia
AAC	Australian Aluminium Council
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABARE	Australian Bureau of Agricultural and Resource Economics
ABR	Australian Business Register
ABS	Australia Bureau of Statistics
ACARP	Australian Coal Association Research Program
ACT	Australian Capital Territory
AD	Activity Data
ADB	Asian Development Bank
ADC	Aluminium Development Council
ADO	Automotive Diesel Oil
ADR	Australian Design Rule
AEMO	Australian Energy Market Operator
AES	Australian Energy Statistics
AEZ	Agro Ecological Zones
AFIC	Australian Feeds Information Centre
AFRC	Agriculture and Food Research Council
AGA	Australian Gas Association
AGEIS	Australia Greenhouse Emissions Information System
AGO	Australian Greenhouse Office
AIHW	Australian Institute of Health and Welfare
ALFA	Australian Lot Feeders Association
ANAO	Australian National Audit Office
ANREU	Australian National Registry of Emissions Units
ANU	Australian National University
ANZSIC	Australia New Zealand Standard Industrial Classification
APEC	Asia Pacific Economic Corporation
API	American Petroleum Institute
APPEA	Australian Petroleum Production and Exploration Association
APS	Australian Petroleum Statistics
ARC	Agricultural Research Council
ARRBTR	Australian Road Research Board Transport Research
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc.
ASRIS	Australian Soil Resource Information System
ASS	Acid Sulphate Soils
AUASB	Auditing and Assurance Standards Board
AUSLIG	Australian Surveying and Land Information Group

AVHRR	Advanced Very High Resolution Radiometer
Avtur	Aviation turbine fuel
BEF	Burning Efficiency
BITRE	Bureau of Infrastructure, Transport and Regional Economics
BoM	Bureau of Meteorology
BTX	Benzene, Toluene, Xylene
BREE	Bureau of Resources and Energy Economics
BRS	Bureau of Rural Science
C&D	Construction and Demolition waste
C&I	Commercial and Industrial waste
CAAANZ	Conservation Agriculture Alliance of Australia and New Zealand
CAB	Change Advisory Board
CCS	Carbon Capture and Storage
CCUS	Carbon Capture Use and Storage
CEF	Clean Energy Future package
CEM	Clean Energy Ministerial
CERI	Clean Energy Research Institute
CFTT	Centre for Forest Tree Technology
COBIT	Control Objectives for Information and related Technology
COD	Chemical Oxygen Demand
CPN	Conditional Probability Network
CRC SI	Cooperative Research Centre for Spatial Information
CRES	Centre for Resource and Environmental Studies
CRF	Common Reporting Format
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CUEDC	Composite Urban Emissions Drive Cycle
DAFF	Department of Agriculture, Fisheries and Forestry
DCC	Department of Climate Change
DCCEE	Department of Climate Change and Energy Efficiency
DE	Department of the Environment
DEEDI	Department of Employment, Economic Development and Innovation
DEM	Digital Elevation Model
DES	Data Exchange Standards
DEWHA	Department of Environment, Water, Heritage and the Arts
DIS	Department of Industry and Science
DIT	Department of Infrastructure and Transport
DM	Dry Matter
DMD	Dry Matter Digestibility
DMITRE	Department of Manufacturing, Innovation, Trade, Resources and Energy
DMP	Department of Mines and Petroleum

DNRM	Department of Natural Resources and Mines
DOC	Degradable Organic Carbon
DOC _f	fraction of Degradable Organic Carbon dissimilated
DOM	Database Operations Manager
DRET	Department of Resources, Energy and Tourism
DSDBI	Department of State Development, Business and Innovation
E&P Forum	Exploration and Production Forum
EDC	Emission Decay Curve
EDS	Early Dry Season
EF	Emission Factor
EGCFE	Expert Group on Clean Fossil Energy
EIS	Environmental Impact Statements
EITEI	Emissions Intensive Trade Exposed Industries
EPA	Environmental Protection Agency
ERIC	Environmental Research and Information Consortium Pty Ltd
ERT	Expert Review Team
ESAA	Energy Supply Association of Australia
ESAS	Electricity Sector Adjustment Scheme
EU ETS	European Union Emissions Trading Scheme
EVAO	Estimated Value of Agricultural Operations
FAO	Food and Agriculture Organisation
FITR	Fourier Transform Infrared Spectroscopy
FOD	First Order Decay
FORS	Federal Office of Road Safety
FPA	Forest Practices Authority
FullCAM	Full Carbon Accounting Model
G8	The Group of Eight
GCL	Geosynthetic Clay Liner
GCV	Gross Calorific Equivalents
GE	Gross Energy
GEDO	Greenhouse and Energy Data Officer
GHG	Greenhouse Gas
GIS	Geographic Information Systems
GRDC	Grains Research and Development Corporation
GWA	George Wilkenfeld and Associates
GWP	Global Warming Potential
HDPE	High Density Polyethylene
IBRA	Interim Biogeographic Regionalisation for Australia
IDF	Industrial Diesel Fuel
IEA	International Energy Agency

IEF	Implied Emission Factor
IPCC	Intergovernmental Panel on Climate Change
IAR	Initial Assessment Report
ISC	Interspecies correlation
ISO	International Organization for Standardization
IUFRO	International Union of Forest Research Organizations
JCP	Jobs and Competitiveness Program
JCPAA	Joint Committee of Public Accounts and Audit
KP	Kyoto Protocol
LDS	Late Dry Season
LKD	Lime Kiln Dust
LNG	Liquefied Natural Gas
LPG	Liquid Petroleum Gas
LTO	Landing/Takeoff
LULUCF	Land use, land use change and forestry
M2M	Methane to Markets
MCF	Methane Correction Factor
MDI	Metered Dose Inhaler
MDP	Metropolitan Development Program
ME	Metabolizable Energy
MEF	Manure Emission Factor
MMS	Manure Management Systems
MRT	Mineral Resources Tasmania
MSW	Municipal Solid Waste
MVG	Major Vegetation Groups
MWTP	Municipal Wastewater Treatment Plants
NAILSMA	North Australian Indigenous Land & Sea Management Alliance
NATA	National Association of Testing Authorities
NCAS	National Carbon Accounting System
NEA	National Energy Administration
NFI	National Forest Inventory
NG	Natural Gas
NGERS	National Greenhouse and Energy Reporting Scheme
NGGI	National Greenhouse Gas Inventory
NGGIC	National Greenhouse Gas Inventory Committee
NIAES	National Institute for Agro-Environmental Sciences
NIR	National Inventory Report
NLWRA	National Land and Water Resources Audit
NORP	Nitrous Oxide Research Program
NRC	National Research Council

NSW	New South Wales
NT	Northern Territory
OECD	Organisation for Economic and Co-operation Development
OSCAR	Online System for Comprehensive Activity Reporting
PCC	Post Combustion Capture
PVC	Polyvinyl Chloride
QA/QC	Quality assurance/Quality control
QDME	Queensland Department of Mines and Energy
QDNRME	Queensland Department of Natural Resources, Mines and Energy
QLD	Queensland
RET	Department of Resources, Energy and Tourism
RIRDC	Rural Industries Research and Development Corporation
ROU	Recycled Organics Unit
RRA	Refrigerant Reclaim Australia
RSA	Registry System Administrators
SA	South Australia
SCA	Standing Committee on Agriculture
SCaRP	Soil Carbon Research Program
SECV	State Electricity Commission of Victoria
SEF	Standard Electronic Format
SEWPaC	Department of Sustainability, Environment, Water, Population and Communities
SIAR	Standard Independent Annual Review
SUV	Sports Utility Vehicle
SWDS	Solid Waste Disposal Site
TAS	Tasmania
TOC	Total Organic Carbon
UAG	Unaccounted for Gas
UNFCCC	United Nations Framework Convention on Climate Change
USEPA	United States Environmental Protection Agency
VIC	Victoria
VKT	Vehicle Kilometres Travelled
VOC	Volatile Organic Compounds
WA	Western Australia
WALFA	Western Arnhem Land Fire Abatement
WBCSD	World Business Council for Sustainable Development
WMAA	Waste Management Association of Australia
WRI	World Resource Institute
WSAA	Water Services Association of Australia
YSLB	Years Since Last Burnt

ANNEX 10: References

- AAC (Australian Aluminium Council), 2007. *Sustainability Report 2006*, AAC Canberra.
- ABARES (Australian Bureau of Agricultural and Resource Economics and Sciences), 1990-2008.
Australian Commodity Statistics, ABARES, Canberra.
- 2014a, *Australian Forest and Wood Products Statistics, March and June quarters 2014*, Canberra
 - 2014b, *National plantation statistics 2014 update*, Canberra.
- ABS (Australian Bureau of Statistics) 1991a, *Australian Economic Indicators*. Catalogue No. 1350.0, Canberra.
- 1991b, *Census of Population and Housing, 1991*. Catalogue No. 2101.0, Canberra.
 - 2000, *Australian Economic Indicators*. Catalogue No. 1350.0, Canberra.
 - 2000, *A spatially consistent sub-set of AgStats data 1982/83 to 1996/1997*. In., Canberra.
 - 2002, *AgStats on the GSP*, Canberra.
 - 2004, *Detailed Energy Statistics, Australia, 2001-02*. Catalogue No. 4648.0.55.001, Canberra.
 - 2006, *Survey of Motor Vehicle Use – An Investigation into Coherence*, Research paper 9208.0.55.005, Commonwealth of Australia, Canberra.
 - 2008a, *Australian Demographic Statistics*, Catalogue No. 3101.0, Canberra.
 - 2008b, *Environmental Issues, people's views and practices*. Catalogue No. 4602.0, Canberra.
 - 2008c, *Agricultural commodities: small area data, Australia 2005-2006 agricultural census*. In., Canberra.
 - 2009e, *Australian Demographic Statistics*, Catalogue No. 3101.0, Canberra.
 - 2010a, *Australian Industry – Mining Commodities*. Catalogue No. 8155, Canberra.
 - 2010b, *Water use on Australian Farms, 2008-09*. Catalogue No. 4618.0, Canberra.
 - 2012, *Australian Economic Indicators*. Catalogue No. 1350.0, Canberra.
 - 2013, *Survey of Motor Vehicle Use Australia, 12 months ended 30 June 2012*, Catalogue No. 9208.0, Canberra.
 - 2013a, *Agricultural commodities: small area data, Australia 2011 agricultural census*. In., Canberra.
 - 2014, *International Trade Merchandise [data available on request]*, Canberra.
 - 2014a, *Motor Vehicle Census, Australia, 31 January 2014*. Catalogue No. 9309.0, Canberra.
- ACARP (Australian Coal Association Research Program), 2011. *Guidelines for the implementation of NGER method 2 or 3 for open cut coal mine fugitive GHG emissions reporting*. ACARP project C20006.
- AEC (Australian Environment Council), 1988. *Air Emission Inventories (1985) for the Australian Capital Cities*, Report No. 22, Australian Government Publishing Service, Canberra.
- AECL (Australian Egg Corporation Limited), 2012. *Egg Industry Overview – 2011/2012*, Sydney, NSW.
<http://www.aecl.org>
- AEMO (Australian Energy Market Operator), 2013. *National Electricity Market Review Tool*.
- AFRC (Agriculture and Food Research Council), 1990. *Nutritive requirements of ruminant animals: energy. Agriculture and Food Research Council Technical Committee on Responses to Nutrients, Report Number 5*. Nutrition Abstracts and Reviews (Series B), vol. 60, pp. 729–804.

- AGA (Australian Gas Association), 1988–94. *Gas Distribution Industry Performance Indicators* (annual), Canberra.
- 1988–2002, *Gas Industry Statistics* (annual), Canberra.
- AGO (Australian Greenhouse Office), 2000a. *Land clearing: A social history*. National Carbon Accounting System Technical Report No. 4. Australian Greenhouse Office, Canberra.
- 2000b, *International Review of the Implementation Plan for the 1990 Baseline*. National Carbon Accounting System Technical Report No. 11 (16pp). Australian Greenhouse Office, Canberra.
 - 2002, *Greenhouse Gas Emissions from Land Use Change in Australia: an Integrated Application of the National Carbon Accounting System*, Australian Greenhouse Office, Canberra.
 - 2004, *AGO Factors and Methods Workbook*, August 2004. Canberra, ACT.
 - 2005 *National Carbon Accounting System, Development Plan 2004–2008*, Australian Greenhouse Office, Department of the Environment and Heritage, Canberra.
 - 2006a, *Technical Guidelines, Generator Efficiency Standards*, Australian Greenhouse Office, Department of Environment and Heritage, Canberra.
 - 2006b, *Coal mine methane*. Unpublished report prepared for the Australian Greenhouse Office by Barlow Jonker Pty Ltd. Australian Greenhouse Office, Department of Environment and Heritage, Canberra.
 - 2007, *Energy Efficiency in Government Operations (EEGO) Policy*, Department of the Environment and Water Resources, Canberra.
- AIHW (Australian Institute of Health and Welfare), 2002. *Apparent Consumption of Nutrients Australia 1997-98*, Canberra
- Amlinger, F., Peyr, S. and Cuhls, C., 2008. *Greenhouse gas emissions from composting and mechanical biological treatment*; Waste Management and Research 26:47.
- Andreae, M.O., E. Atlas, H. Cachier, W.R. Cofer III, G.W. Harris, G. Helas, R. Koppmann, J-P Lacaux and D.E. Ward, 1996. *Trace gas emissions from savanna fires. Biomass burning and global change*, Ed. J.S. Levine, M.I.T Press, Cambridge, Ma, USA, pp 279–295.
- and Merlot, P., 2001. *Emission of trace gases and aerosols from biomass burning*. Global Biogeochemical Cycles, 15(4): 955-966.
- Apelbaum Consulting Group, 2006. *Australian Transport Facts 2004*, report prepared for the Australian Transport Energy Data and Analysis Centre, ACG, Melbourne.
- API (American Petroleum Institute), 2004. *Compendium of greenhouse gas emissions methodologies for the oil and gas industry*, Washington, USA.
- 2009, *Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry*. URS Corporation, Texas, USA.
- APPEA (Australian Petroleum Production and Exploration Association), 1990-2014. *Quarterly Drilling Statistics*. <http://www.appea.com.au/industry-in-depth/industry-statistics/>
- 1997, *Greenhouse Gas Emissions and Action Plan Report 1990–95*, Canberra.
 - 1998–2008, *APPEA Greenhouse Gas Emissions and Action Plan Report* (annual), Canberra.
- ARC (Agricultural Research Council), 1980. *The nutrient requirements of ruminant livestock. Agricultural Research Council Technical Review*, Commonwealth Agricultural Bureau, Farnham Royal.
- Armstrong, W., Lunarzewski, L. and Creedy, D., 2006. *Australian decommissioned mine gas prediction*. Report for the Australian Coal Association Research Programme, ACARP project C14080.

- ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc), 2001. *ASHRAE Handbook Fundamentals Inch-Pound Edition*, ISBN 1-883413-87-7, 2001.
- AUSLIG (Australian Surveying and Land Information Group), 2001. *Digital Elevation Model of Australia, version 2.0*. Canberra, Australia.
- Australian Institute of Petroleum, 1996. Personal communication with Hugh Saddler.
- Australian Macadamia Society, accessed 1 December 2013. <http://www.australian-macadamias.org/about-aussie-macadamias/about-macadamias?lang=en&dr=1&Itemid=95>
- Australian Plantation Products and Paper Industry Council, 2006. *Australian Paper Industry Statistics 2004-2005*, <http://www.a3p.asn.au/statistics/>
- Baker, T.G., and Attiwill, P.M., 1985. *Above-ground nutrient distribution and cycling in Pinus radiata D. Don and Eucalyptus obliqua L'Herit. forests in southeastern Australia*. Forest Ecology and Management, 13:41-52.
- Baldwin, G. and Scott, P.E., 1991. *Investigations into the Performance of Landfill Gas Flaring Systems in the UK*. Proceedings Sardinia 91, 3rd International Landfill Symposium, Sardinia, Italy, 14–18 October 1991.
- Bange, H., 2006. *Nitrous Oxide and Methane in European Coastal Waters*. Estuarine Coastal and Shelf Science, vol 70 (3), pp361-374.
- Barlaz, M.A., 1998. *Carbon Storage during Biodegradation of Municipal Solid Waste Components in Laboratory-scale Landfills*, Global Biochemical Cycles, 12(2), 373-380.
- 2005, Note to ICF consulting, dated June 29, 2005.
 - 2008, *Corrections to Previously Published Carbon Storage Factors*. Note to Parties Interested in Carbon Sequestration from Municipal Solid Waste, dated February 28, 2008.
- Barnes, J. and Owens, N. J. P., 1998. *Denitrification and nitrous oxide concentrations in the Humber estuary, UK, and adjacent coastal zones*. Marine Pollution Bulletin, vol 37 (3-7), pp247-260.
- Barton, L., Kiese, R., Gatter, D., Butterbach-Bahl, K., Buck, R., Hinz, C., and Murphy, D.V., 2008. *Nitrous oxide emissions from a cropped soil in a semi-arid climate*. Global Change Biology, Vol. 14, 177–192.
- Bateman, S., 2009. *Evaluation of Landfill Gas Collection Efficiency at the Wollert Landfill, Melbourne*. Presented at the 3rd National Landfill and Transfer Stations Conference, Hobart.
- Beyond Neutral, 2008. *Greenhouse Gas Inventory for Industrial Processes – Cement, Aluminium, Lime and Titanium Dioxide/Synthetic Rutile – 2007 Inventory*. Unpublished report submitted to the Australian Greenhouse Office. O'Brien Consulting Greenhouse, Energy, Environment, Canberra.
- BITRE (Bureau of Infrastructure, Transport and Regional Economics), 2002. *Report 107, Greenhouse Gas Emissions from Transport, Australian Trends to 2020*, Canberra.
- 2013, *Airport traffic data 1985-86 to 2012-13*, Canberra.
- Blue Environment, 2010. *Review of DOC_f factors outlined in National Inventory Report 2008*. Report for the Department of Climate Change and Energy Efficiency.
- Bluescope Steel, 2011. *Financial/Production History*. <http://www.bluescopesteel.com/investors/financial/-production-history>
- Bolinder, M.A., Janzen, H.H., Gregorich, E.G., Angers, D.A. and VandenBygaart A.J., 2007. *An approach for estimating net primary productivity and annual carbon inputs to soil for common agricultural crops in Canada*. Agriculture, Ecosystems and Environment 118: 29-42.

- Boomsma, D.B., and Hunter, I.R., 1990. *Effects of water, nutrients and their interactions on tree growth, and plantation forest management practices in Australasia: a review*. *Forest Ecology and Management* 30: 455-476.
- Bouwman, A.F., Boumans, L.J.M. and Batjes N.H., 2002. *Emissions of N₂O and NO from fertilized fields: Summary of available measurement data*. *Global Biogeochemical Cycles*, 16, 1058, doi:10.1029/2001GB001811.
- Brack, C.L. and Richards, G.P., 2002. *Carbon Accounting Model for Forests in Australia*. *Environmental Pollution*, 116: 187–194.
- Richards, G.P. and Waterworth, R.M., 2006. *Integrated and comprehensive estimation of greenhouse gas emissions from land systems*. *Sustainability Science*, 1: 91-106.
- BREE (Bureau of Resources and Energy Economics), 2013a. *Australian Energy Statistics – Australian Energy Update 2013*, Canberra.
- 2013b, *Beyond the NEM and the SWIS: 2011-12 regional and remote electricity in Australia*, Canberra.
 - 1996-2013, monthly series: *Australian Petroleum Statistics (APS)*. <http://www.bree.gov.au/publications/australian-petroleum-statistics>
 - 2014, *Australian Energy Statistics – Australian Energy Update 2014*, Canberra.
- Brouwer, E., 1965. *Report of Sub-committee on Constants and Factors in Energy Metabolism, Proceedings of the 3rd International Symposium on Energy Metabolism*. ed. K.L. Blaxter, European Association for Animal Production, Scotland 1964, Publication No.11, pp. 441–443.
- Buonicore A.J. and Davis W.T., 1992. *Air Pollution Engineering Manual*. Van Nostrand Reinhold, USA.
- Burnbank Consulting, 2000. *Synthetic gas use in non-Montreal Protocol industries*. Australian Greenhouse Office, April 2000.
- 2002, *Inventories and projections of ozone depleting substances and synthetic greenhouse gases used in Montreal Protocol industries*. Environment Australia, Canberra.
 - 2007, Uncertainty analysis – solid waste. Burnbank Consulting Pty. Ltd, 15 January 2007.
- Burrows, W., Hoffman, B., Compton, J., and Back, P., 2001. *Allometric Relationships and Community Biomass Stocks in White Cypress Pine (Callitris glaucophylla) and Associated Eucalypts of the Carnarvon Area – South Central Queensland*. National Carbon Accounting System Technical Report No. 33, Australian Greenhouse Office, Canberra.
- Henry, B.K., Back, P.V., Hoffmann, T.B., Tait, L.J., Anderson, E.R., Menke, N., Danaher, T., Carter, J.O., and McKeon, G.M., 2002. *Growth and carbon stock change in eucalypt woodlands in northeast Australia: ecological and greenhouse sink implications*. *Global Change Biology* 48, 769-784.
- Cabaraux, J.F., Philippe, F.X., Laitat, M., Canart, B., Vandenheede, M. and Nicks, B., 2009. *Gaseous emissions from weaned pigs raised on different floor systems*. *Agriculture, Ecosystems & Environment*, vol. 130, no. 3-4, pp. 86-92.
- Caccetta, P.A., 1997. *Remote sensing, geographic information systems (GIS) and Bayesian knowledge-based methods for monitoring land condition*, PhD thesis, Curtin University of Technology, pp 184–203.
- Bryant, G., Campbell, N.A., Chia, J., Furby, S., Kiiven, H.J., Richards, G.P., Wallace, J. and Wu, X., 2003. *Notes on Mapping and Monitoring Forest Change in Australia Using Remote Sensing and Other Data*. In the 30th International Symposium of Remote Sensing and the Environment, Hawaii, November 10-14.
 - and Chia, J., 2004. *Remote Sensing Methods for Plantation Attribution – Experiments and results for Mapsheet Si50*. CSIRO Mathematical and Information Sciences.

- and Furby, S., 2004. *Monitoring Sparse Perennial Vegetation Cover*. In The 12th Australasian Remote Sensing and Photogrammetry Conference Proceedings, Fremantle, Western Australia, 18–22 October.
- Campbell, R.G. (compiler), 1997. *Evaluation and development of sustainable silvicultural systems for multiple purpose management of Mountain Ash forests. A discussion paper*. VSP Technical Report no. 28. Centre for Forest Tree Technology. Forests Service. Department of Natural Resources & Environment, Victoria.
- Carnovale, F., Alviano, P., Carvalho, C., Deitch, G., Jiang, S., Macaulay, D., and Summers, M., 1991. *Air Emissions Inventory. Port Phillip Region: Planning for the Future*, Report SRS 91/001, Environment Protection Authority, Victoria, Melbourne
- Carter, J.O., and Henry, B., 2003. *Savannah Burning in Queensland, Biomass, Nitrogen Content and Charcoal Formation*. Unpublished Report, Department of Natural Resources and Mines, Queensland, 15pp
- Hall, W.B., Brook, G.M., McKeon, K.A., and Paull, C.J., 2000. *Aussie GRASS: Australian Grassland and Rangeland Assessment by Spatial Simulation*. Published in *Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems – The Australian Experience*, edited by G. Hammer, N. Nicholls and C. Mitchell, Kluwer Academic Press, The Netherlands, pp 329–349.
- CASA (Civil Aviation Safety Authority), 2010-2013. *Civil Aircraft Register*. <http://www.casa.gov.au/>
- CER (Clean Energy Regulator), 2014. Data collated by the Clean Energy Regulator under the National Greenhouse and Energy Reporting system for 2009-2013.
<http://www.cleanenergyregulator.gov.au/National-Greenhouse-and-Energy-Reporting/Pages/default.aspx>
- Chappell, A., and Baldock, J., 2013. *Modelling Australian soil organic carbon dynamics*. Report to the Australian Government, Department of Environment. CSIRO, Australia.
- Charmley, E., Williams, S.R.O., Moate, P.J., Hegarty, R.S., Herd, R.M., Oddy, H., Reyenga, P., Staunton, K.M. and Anderson, A., 2014. *A unified relationship between methane emissions and intake for Australian cattle receiving over 70% of their diet as forages*. A report to Department of the Environment.
- Chatto, K., 1997. *Inventory of areas burnt and fuels consumed by bushfires in Australia 1983 to 1996*. A report prepared for CSIRO Division of Atmospheric Research. Centre for Forest Tree Technology (CFTT), Creswick, Victoria, Australia, 17 pp.
- Christensen, K. and Thorbek, G., 1987. *Methane excretion in the growing pig*. *British Journal of Nutrition*, vol. 57, pp. 355–361.
- Christie, K.M., Gourley, C.J.P., Rawnsley, R.P., Eckard, R.J. and Awty, I.M., 2012. *Whole-farm systems analysis of Australian dairy farm greenhouse gas emissions*. *Animal Production Science*, vol 52, pp 998-1011.
- CIF (Cement Industry Federation), 2003. *Cement Industry Environment Report*. Cement Industry Federation.
- 2009, *Australian Cement Industry sustainability Report 2009*, Cement Industry Federation.
- Coal Services Pty Ltd, 2013. *Australian Black Coal Statistics, unpublished*. <http://www.coalservices.com.au/>
- Coops, N.C., Waring, R.H., and Landsberg, J.J., 1998. *Assessing forest productivity in Australia and New Zealand using a physiologically-based model driven with averaged monthly weather data and satellite derived estimates of canopy photosynthetic capacity*. *Forest Ecology and Management* 104:113–127.
- Waring, R.H. Brown, S. and Running, S.W., 2001. *Comparisons of predictions of net primary productivity and seasonal patterns in water use derived with two forest growth models in south-western Oregon*. *Ecological Modelling*, 142:61–8.
- and Waring, R.H., 2001. *The use of multiscale remote sensing imagery to derive regional estimates of forest growth capacity using 3-PGS*. *Remote Sensing of Environment*, 75: 324-334.

- CSIRO (Commonwealth Scientific and Industrial Research Organisation), 2012. *Australian PFC, HFC and SF6 emissions*. CSIRO Light Metals Flagship and Marine and Atmospheric Research, Victoria.
- 2011, *Review of Confidential Data Handling Practices I*. CSIRO Mathematics, Informatics and Statistics, Canberra.
 - 2011b, *Review of Confidential Data Handling Practices I*. CSIRO Mathematics, Informatics and Statistics, Canberra.
 - 2009, *An Analysis of Greenhouse Gas Mitigation and Carbon Biosequestration Opportunities from Rural Land Use*. CSIRO Flagships, Sustainable Agriculture, St Lucia Queensland.
 - 2005, *Australian Greenhouse Information System: Quantitative Estimates of Uncertainty*. CSIRO Atmospheric Research, Aspendale Victoria.
- DAFF (Department of Agriculture, Fisheries and Forestry), 2014. *'Catchment Scale Land Use of Australia – Update March 2014'*. Department of Agriculture, Fisheries and Forestry, Canberra, ACT.
- 2009b, *Survey of the Australian Wastewater Treatment Industry 2009*, Department of Climate Change, Canberra.
 - 2005. *Australian agriculture and food sector stock take*. Department of Agriculture, Fisheries and Forestry, Canberra, ACT.
- Dairy Technical Working Group, 2015. *Review of the methods and data used to estimate dairy cattle emissions in the national inventory*. A report to Department of the Environment.
- Day, S., Dell'Amico, Fry, R., Javanmard Tousi, H., 2014. *Field Measurements of Fugitive Emissions from Equipment and Well Casings in Australian Coal Seam Gas Production Facilities*. CSIRO, Australia.
- DCC (Department of Climate Change), 2010. *Australia's fifth National Communication to the UNFCCC*, Department of Climate Change, Canberra.
- 2009, *Survey of the Australian Wastewater Treatment Industry 2009*. Department of Climate Change, Canberra.
 - 2006, *Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2006*. Department of Climate Change, Canberra.
- DCCEE (Department of Climate Change and Energy Efficiency), 2012. *National Inventory Report 2010*, Department of Climate Change and Energy Efficiency, Canberra.
- 2011 *Energy use in the Australian Government's operations* Department of Resources, Energy and Tourism, Canberra.
- DE (Department of the Environment), 1998-2012. *National Pollutant Inventory*. <http://www.npi.gov.au>
- DEEDI (Department of Employment, Economic Development and Innovation), 2011. *Coal Statistics*. Queensland Government. <http://mines.industry.qld.gov.au/mining/coal-statistics.htm>
- Delmas, R., 1994. *An overview of present knowledge on methane emission from biomass burning*. Fertilizer Research, 37: 181-190.
- Lacaux, J.P., and Brocard, D., 1995. *Determination of biomass burning emission factors: methods and results*. Environmental Monitoring and Assessment, 38, 181-204.
- de Looper, M. and Bhatia, K., 1998. *International health – how Australia compares*. Australian Institute of Health and Welfare, Commonwealth of Australia, Canberra, Australia.
- De Maria, S., 1992. *Unpublished report on Vehicle & Engine Monitoring & Analysis System (VEPMAS)*. By the Energy and Engines Research Group, for buses running on compressed natural gas in Adelaide, Sydney and Brisbane.

- Department of Defence, 2010-2012. *Personal communications regarding domestic fuel data consumption*. Department of Defence, Canberra, ACT.
- Department of National Development, 1969. *Compendium of Australian forest products 1935-36 to 1966-67*, Canberra.
- Devereux, D., Furby, S., and Caccetta, P., 2013. *ARG25 – NCAS-LCCP Geometric and Radiometric Interoperability*. CSIRO Technical Report.
- DEWHA (Department of the Environment, Water, Heritage and the Arts), 2009. *National Waste Overview 2009*. http://www.ephc.gov.au/sites/default/files/WasteMgt_Nat_Waste_Overview_PRINT_ver_200911.pdf
- 2005-2008. *Unpublished data on hydrofluorocarbon imports: in bulk and pre-charged equipment*, Canberra.
- DEWR (Department of the Environment and Water Resources), 2007. *National Pollutant Inventory Emission Estimation Technical Manual for Intensive Livestock – Beef Cattle* Version 3.1, May 2007. Department of the Environment and Water Resources, Canberra, last accessed 5 December 2013. <http://www.npi.gov.au/system/files/resources/21e81086-8418-a424-553e-33aa4482e70f/files/beef.pdf>
- Deslandes J., and Kingston E., 1997. *Energy and Greenhouse Gas Data & Conversion Factors Relevant to BHP Operations*. BHP Technical Note, April 1997.
- Dever, S., Roberts, A. and Cooksley, G., 2009. *Evaluation of Landfill Gas Emissions at Newcastle City Council's Summerhill WMC Landfill via Direct Measurement and using NGER Method-1*. Presented at the 3rd National Landfill and Transfer Stations Conference, Hobart.
- DHV, 2010. *Update of emission factors for N₂O and CH₄ for composting, anaerobic digestion and waste incineration*, Netherlands.
- DIICCS RTE (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education), 2013. *National Inventory Report 2011*, Canberra.
- DIRD (Department of Infrastructure and Regional Development), 2014. *Australian Design Rules, 1969-1988*. <http://www.infrastructure.gov.au/roads/motor/design/>
- DIR (Department of Industry and Resources), 2006. *Petroleum Guidelines – Drilling Fluid Management*, Western Australia.
- DIS (Department of Industry and Science), 2014. *Australian Energy Statistics – Australian Energy Update 2014*, Canberra.
- DIT (Department of Infrastructure and Transport), accessed 2012a. *Summary of Emission Requirements for New Petrol Passenger Cars 1972-2018*. http://www.infrastructure.gov.au/roads/environment/files/Emission_Standards_for_Petrol_Cars_1972_2018.pdf
- accessed 2012a, *Emission Requirements for Diesel Heavy Duty Vehicles*. http://www.infrastructure.gov.au/roads/environment/files/Standards_for_Diesel_HDVs.pdf
- Dixon, B., 1990. 'Methane losses from the Australian natural gas industry', in D.J. Swaine (ed.) *Greenhouse and Energy*, CSIRO 1990.
- DMITRE (Department for Manufacturing, Innovation, Trade, Resources and Energy), 2013. Coal mining production data, Mineral Resources Division, South Australia. http://outernode.pir.sa.gov.au/minerals/publications_and_information/resource_production_statistics
- DMP (Department of Mines and Petroleum), 2013. Coal mining production data, Western Australia. <http://www.dmp.wa.gov.au/>

- DNRM (Department of Natural Resources and Mines), 2014b. Coal mining production data, Mines and Energy, Brisbane. <http://mines.industry.qld.gov.au/mining/coal.htm>
- Doorn, M.R.J. and Barlaz, M.A., 1995. *Estimate of Global Methane Emissions from Landfills and Open Dumps*. USEPA, Washington.
- DPI (Department of Primary Industries), 2012. *Victoria's Minerals, Petroleum and Extractive Industries: Statistical Review 2010-2011*, Victoria.
- DRET (Department of Resources, Energy and Tourism), 2012. *Energy use in the Australian Government's operations* Department of Resources, Energy and Tourism, Canberra.
- Driscoll, D., Milkovits, G. and Freudenberger, D., 2000. *'Impact of Use of Firewood in Australia'*. CSIRO Sustainable Ecosystems, Canberra.
- DSDBI (Department of State Development, Business and Innovation), 2013. Coal production data, Energy and Earth Resources, Victoria. <http://dpistore.efirst.com.au/categories.asp?cID=46&c=181223>
- DSEWPC (Department of Sustainability, Environment, Water, Population and Communities), 2013. *National Pollution Inventory Emission Estimation Technical Manual for Intensive Livestock – Poultry Raising*, Version 3, June 2013, Department of Sustainability, Environment, Water, Population and Communities, Canberra.
- DTI (Department of Trade and Investments), 2014. Well drilling data, Division of Resources and Energy, NSW. <http://dwh.minerals.new.gov.au/CI/warehouse>
- Duffy, Nelson and Williams, 1995. *Trace Organic Composition of Landfill Gas*. Report to NSW Environmental Research Trusts. CSIRO. Sydney.
- Dyer, R., Café, L., and Craig, A., 2001. *Australian Grassland and Rangeland Assessment by Spatial Simulation (Aussie GRASS) Northern Territory and Kimberly Sub-project*, QNR9, Final Report for the Climate Variability in Agriculture Program, Department of Natural Resources and Mines, Queensland.
- Eamus, D., McGuinness, K. and Burrows, W., 2000. *Review of Allometric Relationships for Woody Biomass for Queensland, the Northern Territory and Western Australia*. National Carbon Accounting System Technical Report No. 5a (60pp). Australian Greenhouse Office, Canberra.
- E and P (Exploration and Production) Forum, 1994. *Methods for Estimating Emissions from E&P Operations*, The Oil Industry International Exploration and Equipment Forum, London.
- EASA (European Aviation Safety Agency), 1975-2013. *International Civil Aviation Organization (ICAO) Aircraft Engine Emissions Databank*. <http://www.easa.europa.eu/environment/edb/aircraft-engine-emissions.php>
- EEA (European Environment Agency), 2011. *COPERT 4 – Estimating emissions from road transport*. <http://www.eea.europa.eu/publications/copert-4-2014-estimating-emissions>
- EITEIs, 2007 and 2008. Data collated by the Department of Climate Change under Emissions Intensive Trade Exposed Industries Program.
- EnerGreen Consulting, 2009 and 2008. *Greenhouse Gas Inventory for Industrial Processes and Solvents and Other Product Use*, EnerGreen Consulting, Nov 2009.
- 2011. *Nitrous Oxide Emissions from Nitric Acid Production: A Review of Emissions Abatement Technology*, EnerGreen Consulting April 2011.
- Energy Strategies, 2005. *Review of methodology for estimating Australia's unaccounted for gas (UAFG) as calculated in the NGGI*, report to the Australian Greenhouse Office.
- 2007. *Report on Chemical activity data collection and analysis*, report to the Australian Greenhouse Office.

- EPA (NSW Environment Protection Authority), 1995. *Metropolitan Air Quality Study – Air Emissions Inventory*, Environment Protection Authority NSW.
- 2000. *State of the Environment 2000*, Environment Protection Authority, NSW. (http://www.environment.nsw.gov.au/soe/soe2000/ch/ch_fig_2.27.htm)
- EPA (Victorian Environment Protection Authority), 1991. *Air Emissions Inventory for the Port Phillip Control Region, SRS 91/001*, Environment Protection Authority, Victoria, Melbourne.
- ERIC (Environmental Research and Information Consortium Pty Ltd), 2001. *Rates of Clearing of Native Woody Vegetation 1997–2000*. (22pp) Report to the NSW Department of Land and Water Conservation, Parramatta.
- ESAA (Energy Supply Association of Australia), 2005–2013. *Electricity Gas Australia* (Annual), Canberra.
- EEA (European Environment Agency), 2009. *EMEP/EEA air pollutant emission inventory guidebook*. Copenhagen.
- Expert Group, 2013. *Cold Hard Facts 2, A Study of the refrigeration air conditioning industry in Australia*. Report to the Department of Sustainability, Environment, Water, Population and Communities, Canberra.
- Farrington, V., 1988. *Air Emission Inventories (1985) for the Australian Capital Cities*, Australian Environment Council Report 22, AGPS, Canberra.
- Fensham, R.J., Fairfax, R.J., and Ward, D.P. 2008, 'Drought-induced tree death in savanna', *Global Change Biology* 15 (2): 380–387.
- Ferguson, I., Fox, J.C., Baker, T., Stackpole, D., and Wild, I., 2002. *Plantations of Australia – Wood Availability 2001–2004*. Bureau of Rural Sciences, Canberra, Australia.
- Fernández-Puriatch, H., Oliver-Villanueva, J. V., Alfonso-Solar, D. and Peñalvo-López, E., 2013. *Quantification of potential lignocellulosic biomass in fruit trees grown in Mediterranean regions*. *Bioresources.com*, **8** (1), 88–103.
- Fisher and Paykel, 2010. *Annual Report 2010*. <http://www.fisherpaykel.com/global/investors/Investors-PDFs/Annual%20Reports/Annual%20Review%20Year%20Ended%2031%20March%202010.pdf>
- Flessa, H., Dorsch, P., Beese, F., Koenig H., and Bouwman A.F., 1996. *Influence of cattle wastes on nitrous oxide and methane fluxes in pasture land*, *Journal of Environmental Quality*, vol 25, pp 1366–1370.
- Florence, R. G., 1996. *Ecology and silviculture of eucalypt forests*, CSIRO Publishing, Collingwood, Victoria.
- Foley, J. and Lant, P., 2007. *Fugitive Greenhouse Gas Emissions from Wastewater Systems*, Water Services Association of Australia, WSAA Literature Review No.1, December 2007.
- Ford, A., 2004. *Site quality for Pinus radiata D. Don: Southern Tablelands NSW*. School of Resources, Environment and Society, Australian National University, Canberra, ACT.
- FORS (Federal Office of Road Safety), 1996. *Motor Vehicle Pollution in Australia – Report on the National In-Service Vehicle Emissions Study*, FORS Canberra.
- Forestry Tasmania, 2008. *2008 Report – Sustainable forest management*. Forestry Tasmania, Hobart, Tasmania.
- Forests NSW (New South Wales), 2008. *Forests NSW: Annual Report 2007–08*. Forests NSW, Sydney, Australia.
- FPA (Forest Practices Authority), 2007. *The Annual Report of the Forest Practices Authority 2006–07*. Tasmania, Australia.
- Freer, M., Moore, A.D. and Donnelly, J.R., 1997. *GRAZPLAN: Decision support systems for Australian grazing enterprises II. The animal biology model for feed intake, production and reproduction and the GrazFeed DSS, Agricultural Systems*, vol 54, pp 77–126.

- Furby, S., 2002. *Land Cover Change: Specifications for Remote Sensing Analysis*. National Carbon Accounting System Technical Report No. 9 (236pp), Australian Greenhouse Office, Canberra.
- and Woodgate, P., 2002. *Pilot Testing of Remote Sensing Methodology for Mapping Land Cover Change*. National Carbon Accounting System Technical Report No. 16 (354pp), Australian Greenhouse Office, Canberra.
 - and Campbell, N.A., 2001. *Calibrating images from different dates to 'like value' digital counts*. Remote Sensing of Environment 77: 186-196.
- Galbally, I.E., Meyer, C.P., Bentley, S., Weeks, I., Leuning, R., Kelly, K., Phillips, F., Barker-Reid, F., Gates, W., Baigent, R., Eckard R., and Grace, P., 2005. *A study of environmental and management drivers of non-CO₂ greenhouse gas emissions in Australian agro-ecosystems*, *Environmental Sciences* 2, 133–142.
- Meyer, C.P., Wang, Y-P., Weeks, I.A., Smith, C., Howden, S.M., Elsworth, C.M., Petraitis, B., Johnson, E., McLachlan, G., Huang G., and McKenney, D.L., 1994. *RIRDC Project CSD-47A – The role of legume pasture in greenhouse gas emissions from Australia*. Final report, CSIRO Division of Atmospheric Research, Aspendale, Victoria, Australia 56 pp.
- Gardner, W.D., Ximenes, F., Cowie, A., Marchant, J.F., Mann, S., and Dods, K., 2004. *Decomposition of Wood Products in the Lucas Heights Landfill Facility*, 3rd Intercontinental Landfill Research Symposium. Japan (2004).
- George Wilkenfeld and Associates (GWA), 2009. *National Greenhouse Gas Inventory: 2009 Electricity sector emissions*. Prepared for the Department of Climate Change, George Wilkenfeld and Associates Pty Ltd, December 2009.
- GHD, 2010. *Report for Review of DOC_f values used in the Australian National Greenhouse Accounts*, report to the Department of Climate Change.
- 2009a. *Report for National Greenhouse Accounts 2008: Methane Capture from Landfills*, report to the Department of Climate Change.
 - 2009b. Lime usage in Australian planted forests. A report for NCAS Technical Services, Canberra, ACT.
 - 2009c. Report for emissions from the production of cement, lime, magnesia, synthetic rutile and aluminium in the industrial processes sector. Report to the Department of Climate Change.
 - 2008. Report for review of current municipal waste and commercial and industrial waste mix composition in the NGER Measurement Determination. Report to the Department of Climate Change, January 2008.
 - 2006a. Review of liquid fuels CO₂ emissions factors. report to the Australian Greenhouse Office, Department of the Environment and Heritage, Canberra.
 - 2006b. *Review of Sectoral Models*. Report to the Australian Greenhouse Office, Department of the Environment and Heritage, Canberra.
- Gifford, R., 2000a. *Carbon Content of Woody Roots: Revised Analysis and a Comparison with Woody Shoot Components (Revision 1)*. National Carbon Accounting System Technical Report No. 7 (10pp). Australian Greenhouse Office, Canberra.
- 2000b. Carbon Content of Aboveground Tissues of Forest and Woodland Trees. National Carbon Accounting System Technical Report No. 22 (28pp). Australian Greenhouse Office, Canberra.
 - and Howden, M., 2001. *Vegetation thickening in an ecological perspective: significance to national greenhouse gas inventories*. *Environmental Science and Policy* 4 (2-3): 59-72.
- Golder Associates, 2009. *Kimbriki Recycling and Waste Facility – Landfill Gas Emissions Assessment*. Report for Kimbriki recycling and waste management facility, NSW.

- Gonzalez-Avalos, E., and Ruiz-Suarez, L.G., 2001. *Methane emissions factors from cattle manure in Mexico*. *Bioresource Technology*, vol 80, pp 63–71.
- Gower, S.T., Gholz, H.L., Nakane, K., and Baldwin, V.C., 1994. *Production and allocation patterns of pine forests*. *Ecological Bulletins* 43: 115-135.
- Grace, P.R., Post, W.M., Godwin, D.C., Bryceson, K.P., Truscott, M.A., and Hennessy, K.J., 1998. *Soil carbon dynamics in relation to soil surface management and cropping systems in Australian agroecosystems*. Management of Carbon Sequestration in Soil. Symposium on Carbon Sequestration in Soils, Columbus Oh, (175-193). Jul, 1996
- Graham, N.M., 1964a. *Energetic efficiency of fattening sheep. I. Utilization of low-fibre and high-fibre food mixtures*. *Australian Journal of Agricultural Research*, vol 15, pp 100–112.
- 1964b. *Energetic efficiency of fattening sheep. II. Effects of undernutrition*, *Australian Journal of Agricultural Research*, vol 15, pp 113–126.
 - 1967. The net energy value of three subtropical forages. *Australian Journal of Agricultural Research*, vol 18, pp 137–147.
 - 1969. The net energy value of artificially dried subterranean clover harvested before flowering. *Australian Journal of Agricultural Research*, vol 20, pp 365–373.
- Gras, J.L., 2002. *Emissions from Domestic Solid Fuel Burning Appliances, Technical Report No. 5*; CSIRO Report for Environment Australia. <http://www.environment.gov.au/atmosphere/publications/index.html>
- Grierson, P.F., Williams, K., and Adams, M.A., 2000. *Review of Unpublished Biomass Related Information: Western Australia, South Australia, New South Wales and Queensland*. National Carbon Accounting System Technical Report No. 25 (114pp). Australian Greenhouse Office, Canberra.
- Griffin, E. A., Verboom, W. H., and Allen, D., 2002. *Paired Site Sampling for Soil Carbon Estimation – WA*. National Carbon Accounting System Technical Report No. 38, Australian Greenhouse Office, Canberra.
- Grjotheim, K., and Welch B.J., 1980. *Aluminium Smelter Technology: A Pure and Applied Approach*, Aluminium Verlag GMBH, Dusseldorf.
- Guendehou, S., 2010. *Australia's National Greenhouse Gas Inventory 2008: Solid Waste Review – Fraction of DOC dissimilated DOC_p* report to the Department of Climate Change.
- 2009. *Australia's National Greenhouse Gas Inventory 2007: Solid Waste Quality Assurance Review*, report to the Department of Climate Change.
- Hall, W.B., Brook, G.M., McKeon, K.A., and Paull, C.J., 2000. *Aussie GRASS: Australian Grassland and Rangeland Assessment by Spatial Simulation. Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems – The Australian Experience*, edited by G. Hammer, N. Nicholls and C. Mitchell, Kluwer Academic Press, The Netherlands, pp 329–349.
- Harms, B., and Dalal, R., 2003. *Paired Site Sampling for Soil Carbon Estimation – Qld*. National Carbon Accounting System Technical Report No. 37, Australian Greenhouse Office, Canberra.
- Dalal, R.C. and Cramp, A.P. 2005. *Changes in Soil Carbon and Soil Nitrogen after Tree Clearing in the Semi-arid Rangelands of Queensland*. *Australian Journal of Botany* (53) 639–650.
- Haynes, C. D., 1985. *The pattern and ecology of munwag: traditional Aboriginal fire regimes in north-central Arnhem Land*. *Proceedings of the Ecological Society of Australia*, 13, pp 203–214.
- Haynes, R. J., and Goh, K. M., 1980. *Distribution and budget of nutrients in a commercial apple orchard*. *Plant and Soil*, **56**, 445-457.

- Heanes, D. L., 1984. *Determination of total organic-C in soils by an improved chromic acid digestion and spectrophotometric procedure*. Communications in Soil Science and Plant Analysis, 15, 1191-1213.
- Heenan, D.P., McGhie, W.J., Thomsons, F.M., Chan, K.Y., 1995. *Decline in soil organic carbon and total nitrogen in relation to tillage, stubble management, and rotation*. Australian Journal of Experimental Agriculture, 35, 877-84 877
- Heathcote in, Camm, J.C.R., McQuilton, J., editors, 198, Australians : A Historical Atlas, Broadway, NSW, Fairfax, Syme and Weldon Associates, pp 62-63.
- Henzell, T., 2007. *Australian Agriculture Its History and Challenges*, CSIRO Publishing.
- Hickey, J.E., 1994. *A floristic comparison of vascular species in Tasmanian oldgrowth mixed forest with regeneration resulting from logging and wildfire*. Australian Journal of Botany, 42: 383-404.
- Hill, M.J., and Donald, G.E., 1998. *Australian Temperate Pastures Database*. CSIRO, CD ROM, Canberra.
- Hingston, F.J., Dimmock, G.M., and Turton, A.G., 1981. *Nutrient distribution in a jarrah (Eucalyptus marginate Donn Ex Sm.) ecosystem in south-west Western Australia*. Forest Ecology and Management, 3: 183-207.
- Hoekman, S.K., 1992. *Speciated Measurements and Calculated Reactivities of Vehicle Exhaust Emissions from Conventional and Reformulated Gasolines*, Environmental Science and Technology, Vol. 26, No. 10, p 2036, American Chemical Society.
- Houlder, D., Hutchinson, M.F., Nix, H.A., and McMahon, J.P., 2000. *ANUCLIM, User's Guide*. CRES, ANU, Canberra.
- Howden, S.M., 2001. *Analysis of National Livestock Statistics: Assessment for systematic reporting bias*, in F. Ghassemi, D.H. White, S. Cuddy and T. Nakanishi (eds) *Integrating models for natural resources Management across disciplines, issues and scales*. Proceedings of the International Congress on Modelling and Simulation, December 2001, Canberra. Modelling and Simulation Society of Australia and New Zealand, Canberra. p 1841-1846.
- and Barret, D., 2003. Review of Australian methodology for estimating greenhouse gas emissions from livestock: Analysis of Tasmania and National Beef and Dairy Herd Data, CSIRO, report prepared for the Australian Greenhouse Office.
 - White, D.H., and Hegarty, R., 2002. The review of the National Greenhouse Gas Inventory for Australian Livestock, CSIRO Sustainable Ecosystems, report prepared for the Australian Greenhouse Office.
 - White, D.H., McKeon, G.M., Scanlan, J.C., and Carter J.O., 1994. Methods for Exploring Management Options to Reduce Greenhouse Gas Emissions from Tropical Grazing Systems, *Climatic Change*, vol 27 pp 49–70.
- HRL, 2013. *Latrobe Valley Brown Coal Mine Method One Default Fugitive Greenhouse Gas Emission Factor*. Unpublished report.
- Hughes, K. A., Gandar, P. W. and de Silva H. N., 1995. *Exploration and exploitation of soil by apple, kiwifruit, peach, Asian pear and grape roots*. Plant and Soil, 175, 301-309.
- Hunter, R.A., 2007. *Methane production by cattle in the tropics*, British Journal of Nutrition, Vol 98, pp 657.
- Hurst, D.F., Griffith D.W.T., Carras, J.N., Williams, D.J., and Fraser, P.J., 1994a. *Measurements of trace gases emitted by Australian savanna fires during the 1990 dry season*, *Journal of Atmospheric. Chemistry*, 18, pp 33–56.
- and Cook, G.D., 1994b. Trace gas emissions from biomass burning in tropical Australian savannas, *Journal of Geophysical Research*, 99, pp 16441 – 16456.

- and Cook, G.D., 1996. *Trace gas emissions from biomass burning in Australia*, Biomass Burning and Global Change, Ed. J.S. Levine, M.I.T Press, USA. Vol 2 p787-792.
- Hutchinson, M.F., Stein, J.A., and Stein, J.L., 2001. *Upgrade of the 9 second Digital Elevation Model for Australia*. Centre for Resource and Environmental Studies, Australian National University, Canberra.
- Hutchinson N., Piff R., Bavaro M., Lehner M., and Pack D., 1993. *Environmental committee on natural gas leakage, position report on methane emissions*, AGA, Canberra.
- Hyder Consulting, 2007a. *AGO Factors and Methods Workbook – Waste Chapter Review*, unpublished report to the Australian Greenhouse Office, Hyder Consulting Sydney.
- 2007b. *Review of Methane Recovery and Flaring from Landfills*, unpublished report to the Australian Greenhouse Office, Hyder Consulting Sydney.
- 2008. *Composition of commercial & industrial and municipal waste to landfill*, report to the Department of Climate Change, January 2008.
- 2009. *Review of first order decay model parameters Fraction of degradable organic carbon dissimilated (DOC_p)* report to the Department of Climate Change.
- 2010. *Greenhouse Accounts: Emissions from solid waste disposal – DOC_p* Report to the Department of Climate Change and Energy Efficiency.
- IEA (International Energy Agency), 1992. *Global methane and the coal industry, OECD, Part 1*, pp 34. Coal Industry Advisory Board. <http://www.iea.org/textbase/nppdf/free/1990/ciab1994.pdf>
- 1993. *Coal Research, N₂O from Fuel Combustion*. IEAPER/06, ISMN 92-9029-227-X.
- 2005. *Energy Statistics Manual*, France. http://www.iea.org/Textbase/publications/free_new_Desc.asp?PUBS_ID=1461
- Ilic, J., Boland, D.J., McDonald, M., and Downes, G., 2000. *Wood Density – State of Knowledge*. National Carbon Accounting System Technical Report No. 18 (55pp). Australian Greenhouse Office, Canberra.
- International Aluminium Institute, 2005. *The International Aluminium Institutes Report on the Aluminium Industry's Global Perfluorocarbon Gas Emissions Reduction Programme – Results of the 2003 Anode Effect Survey*. International Aluminium Institute, New Zealand House, London.
- 2006. *The Aluminium Sector Greenhouse Gas Protocol, Addendum to the WRI/WBCSD GHG Protocol*, International Aluminium Institute.
- USEPA, 2008. *Protocol for Measurement of Tetrafluoromethane (CF₄) and Hexafluoroethane (C₂F₆) Emissions from Primary Aluminium Production*, Washington, D.C. and London, U.K.
- International Civil Aviation Organisation (ICAO), 2004. *ICAO Aircraft Engine Emissions Databank*, January 2012 <http://easa.europa.eu/environment/edb/aircraft-engine-emissions.php>
- IPCC (Intergovernmental Panel on Climate Change), 1996. *Climate Change 1995: The Science of Climate Change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change*, University Press, Cambridge.
- 1997. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 1, Greenhouse Gas Inventory Reporting Instructions; Volume 2, Greenhouse Gas Inventory Workbook; Volume 3, Greenhouse Gas Inventory Reference Manual* IPCC/OECD/IEA, Paris, France.
- 2000. *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, Japan.
- 2003. *Good Practice Guidance on Land Use, Land Use Change and Forestry*, Japan.
- 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Japan.

- 2010. Use of models and facility-level data in greenhouse gas inventories, report of IPCC expert meeting on the use of models and measurements in greenhouse gas inventories 9-11 Aug 2010, Sydney Australia. Japan IGES.
 - 2014. *2013 Revised supplementary methods and good practice guidance arising from the Kyoto Protocol*, IPCC Switzerland.
- Jaakko Pöyry Consulting, 1999. *National Carbon Accounting System – Usage and Lifecycle of Wood Products*. NCAS Technical Report No.8. Canberra.
- 2000. *Analysis of Wood Product Accounting Options for the National Carbon Accounting System*. National Carbon Accounting System Technical Report No. 24 (37pp). Australian Greenhouse Office, Canberra.
- Janik, L., Spouncer, L., Correll, R., and Skjemstad, J., 2002. *Sensitivity analysis of the Roth-C soil carbon model (Ver. 26.3 Excel®)*: National Carbon Accounting System Technical Report No. 30, Australian Greenhouse Office, Canberra.
- Janzen, H.H., Beauchemin, K.A., Bruinsma, Y., Campbell, C.A., Desjardins, R.L., Ellert, B.H. and Smith, E.G., 2003. The fate of nitrogen in agroecosystems: An illustration using Canadian estimates', *Nutrient Cycling in Agroecosystems*, vol 67, pp 85-102.
- Jenkinson, D.S., 1990. *The turnover of organic carbon and nitrogen in soil*. Philosophical Transactions of the Royal Society, B 329: 361-368.
- Jenkinson, D.S., Adams, D.E. and Wild, A., 1991. *Model Estimates of CO₂ Emissions from Soil in Response to Global Warming*. Nature, 351: 304-306.
- Hart, P.B.S., Rayner, J.H., and Parry, L.C., 1987. *Modelling the Turnover of Organic Matter in Long-Term Experiments at Rothamsted*. INTERCOL Bulletin 15: 1-8.
- Joint Coal Board, 1988–2000. *Australian Black Coal Statistics* (annual), Sydney.
- Jones, S., Lowell, K.E., Woodgate, P., Buxton, L., Mager, A., and Liebchen, S., 2004. *Update on the National Carbon Accounting System Continuous Improvement and Verification Methodology*. National Carbon Accounting System Technical Report 46, Australian Greenhouse Office.
- Keith, H., Barrett, D., and Keenan, R., 2000. *Review Allometric Relationships for Woody Biomass for New South Wales, the Australian Capital Territory, Victoria, Tasmania and South Australia*. National Carbon Accounting System Technical Report No. 5b (119pp). Australian Greenhouse Office.
- Kesteven, J., Landsberg, J., and URS Consulting, 2004. *Developing a national forest productivity model*. National Carbon Accounting System Technical Report No.23, Australian Greenhouse Office, Canberra.
- King, R.H., and Brown, W.G., 1993. *Interrelationships between dietary protein level, energy intake and nitrogen retention in pregnant gilts*, *Journal of Animal Science*, vol. 71, pp. 2450–2456.
- Toner, M.S., Dove, H., Atwood, C.S., and Brown, W.G., 1993. *The response of first-litter sows to dietary protein level during lactation*, *Journal of Animal Science*, vol. 71, pp.2457–2463.
- Kirchgessner, M., Kreuzer, M., Muller, H.L., and Windisch, W., 1991. *Release of methane and of carbon dioxide by the pig*, *Agribiological Research*, vol. 44, pp. 103–113.
- Kiiveri, H., Caccetta, P., Campbell, N., Evans, F., Furby, S., and Wallace, J., 2003. *Environmental Monitoring Using a Time Series of Satellite Images and Other Spatial Data Sets*, in D. D. Denison, M. H. Hansen, C. Holmes, B. Mallick, B. Yu (Eds), *Nonlinear Estimation and Classification*, Lecture Notes In Statistics, New York, Springer Verlag, 2003, ISSU 171, pages 49-62.
- Caccetta, P.A., and Evans, F., 2001. *Use of conditional probability networks for environmental monitoring*, *International Journal of Remote Sensing*, Volume 22: 1173-1190.

- Kirk-Othmer, 1999. *Concise Encyclopedia of Chemical Technology*, Fourth Edition, John Wiley & Sons, Inc. USA.
- Kroodsma, D. A., and Field, C. B., 2006. *Carbon sequestration in Californian agriculture*. Ecological Applications, **16** (5), 1975-1985.
- Kurihara, M., Magner, T., Hunter, R.A., and McCrabb G.J., 1999. *Methane production and energy partition of cattle in the tropics*, *British Journal of Nutrition*, vol 81, pp 263–272.
- Lamborn, J., 2009. *Characterisation of municipal solid waste composition into model inputs*. Third international workshop “Hydro-Physico-Mechanics of Landfills” Braunschweig, Germany, March 2009.
- Landsberg, J.J., 1986. *Coupling of Carbon, Water and Nutrient Interactions in Woody Plant Soil Systems*. Tree Physiology 2.
- and Gower, S.T., 1997. *Applications of Physiological Ecology to Forest Management*. Academic Press: San Diego Press. 354pp.
 - and Waring, R.H., 1997. *A generalized model of forest productivity using simplified concepts of radiation-use efficiency, carbon balance, and partitioning*. Forest Ecology and Management, 95: 209–228.
- Law, B.E., Sun, O.J., Campbell, J., Van Tuyl, S., and Thornton, P.E., 2003. *Changes in carbon storage and fluxes in a chronosequence of ponderosa pine*. Global Change Biology 9: 510-524.
- Leung, L., 2001. BHP, *pers comm. regarding emission factor analysis of Port Kembla and Whyalla coking coals*.
- Leuning, R., Baker, S.K., Jamie, I.M., Hsu, C.H., Klien, L., Denmead, O.T., and Griffith, D.W.T., 1999. *Methane emissions from free-range sheep: a comparison of two measurement methods*. Atmospheric Environment, vol 33, pp 1357–1365.
- Lewis, N.B., Keeves, A., and Leech, J.W., 1976. *Yield regulation in South Australian Pinus radiata plantations*. Woods and Forests Department Bulletin (South Australia) 23.
- Llewellyn, R.S., D’Emden, F., and Gobbett, D., 2009. *Adoption of no-till and conservation farming practices in Australian grain growing regions: current status and trends*. Preliminary report for SA No-till Farmers Association and CAAANZ, South Australia.
- Llewellyn R.S., D’Emden F.H., Kuehne G., 2012. *Extensive use of no-tillage in grain growing regions of Australia*. Field Crops Research, **132**, 204-212.
- Lloyds’ Register of Shipping, 1995. *Marine Exhaust Emissions Research Programme – Steady State Operation*, Lloyds’ Register of Shipping, London, UK.
- Loh, Z., Chen, D., Bai, M., Naylor, T., Griffith, D., Hill, J., Denmead, T., McGinn, S., and Edis, R., 2008. *Measurement of greenhouse gas emissions from Australian feedlot beef production using open-path spectroscopy and atmospheric dispersion modelling*, Australian Journal of Experimental Agriculture, vol. 48, no. 2, pp. 244-247.
- Lovatt, C. J., 1996. *Nitrogen allocation within the ‘Hass’ avocado*. Californian Avocado Society 1996 Yearbook, **80**, 75-83.
- Lowell, K., Buxton, L., Fintelman, R., Ching, J., Arya, T., and Jones, S., 2012. *Update of the national carbon accounting system continuous improvement and verification methodology: 2002-2010* unpublished research report by the Cooperative Research Centre for Spatial Information and RMIT University Australia, November 2012.
- Lowell, K.E., Woodgate, P., Jones, S. and Richards, G.P., 2003. *Continuous Improvement of the National Carbon Accounting System Land Cover Change Mapping*. National Carbon Accounting System Technical Report 39, Australian Greenhouse Office, p. 36.

- Richards, G.P., Woodgate, P., Jones, S., and Buxton, L., 2005. *Fuzzy Reliability Assessment of Multi-Period Land-cover Change Maps*. Photogrammetric Engineering and Remote Sensing, 71:939–945.
- Lucas, R.M., King, S., et al., 1997. *The role of Australia's native forests in carbon sequestration: Tasmania as a case study*. Report to the Department of Environment, Sports and Territories, Canberra, Australia.
- Lunarzewski, L., 2005. *Gas Emission Curves for Sealed Goafs or Abandoned Mines*, report for the Australian Coal Association Research Programme, ACARP project C13007.
- 2006. *Review of the Draft Australian Methodology for Estimating Greenhouse Gas Emissions from Flooding Decommissioned Coal Mines*, unpublished report to the Department of Environment and Heritage.
- Lynch, D., Cuff, N. and Russell-Smith J., in press. *Vegetation fuel type classification for lower rainfall savanna burning abatement projects*. Carbon Accounting and Savanna Fire Management, Eds: B.P. Murphy, A.C. Edwards, M.Meyer and J. Russell-Smith, CSIRO Publishing, Clayton Sth, Victoria, Australia, pp 73 – 96.
- Mackensen, J., and Bauhus, J., 1999. *The Decay of Coarse Woody Debris*. National Carbon Accounting System Technical Report No. 6 (41pp). Australian Greenhouse Office, Canberra.
- Bauhus, J., and Webber, E., 2003. *Decomposition rates of coarse woody debris – A review with particular emphasis on Australian species*. Australian Journal of Botany 51: 23-37.
- Margan, D.E., Graham, N. M., and Searle, T.W., 1985. *Energy values of whole lucerne (Medicago sativa) and of its stem and leaf fractions in immature and fully grown sheep*. Australian Journal of Experimental Agriculture, vol. 25, pp 783–790.
- 1987. *Energy values of whole oats grain in adult wether sheep*, Australian Journal of Experimental Agriculture, vol. 27, pp 223–230.
- and Minson, D.J., 1988. *Energy and protein values of four forages, including a comparison between tropical and temperate species*. Australian Journal of Experimental Agriculture, vol. 28, pp 729–736.
- Marini, R.P., and Sowers, D. S., 2000. *Peach tree growth, yield and profitability as influenced by tree form and tree density*. Horticultural Science, **35 (5)**, 837-842.
- Marsden-Smedley, J.B., and Catchpole, W.R., 1995a. *Fire modelling in Tasmanian buttongrass moorlands I. Fuel characteristics*. International Journal of Wildland Fire, 5, pp 203–214.
- 1995b. *Fire modelling in Tasmanian buttongrass moorlands II. Fire behaviour*. International Journal of Wildland Fire, 5, pp 215–228.
- MBAC Consulting, in preparation. *CSIRO Plantation Imagery Verification*. Australian Greenhouse Office, Canberra, Australia.
- McGahan, E.J., Casey, K.D., van Sliedregt, H., Gardner, E.A., Watts, P.J., and Tucker, R.W., 2004. *Beefbal – A Nutrient Balance Model for Feedlots*, version 1.1, Department of Primary Industries, Toowoomba.
- McGinn, S.M., Chen, D., Loh, Z., Hill, J., Beauchemin, K.A., and Denmead, O.T., 2008. *Methane emissions from feedlot cattle in Australia and Canada*, Australian Journal of Experimental Agriculture, vol. 48, pp 183-185
- McKenzie, N. J., Ryan, P. J., Fogarty, P., and Wood, J., 2000b. *Sampling Measurement and Analytic Protocols for Carbon and Litter Estimation*. National Carbon Accounting System Technical Report No. 14 (66pp). Australian Greenhouse Office, Canberra.
- Jacquier, D.W., Ashton, L.J., and Cresswell, H.P., 2000a. *Estimation of Soil Properties Using the Atlas of Australian Soils*. CSIRO Land and Water Technical Report 11/00.

- McMeniman, J.P., Defoor, P. J., and Gaylean, M.L., 2009. Evaluation of the National Research Council, 1996. *Dry matter intake predictions and relationships between intake and performance by feedlot cattle*, Journal of Animal Science, 87.3:1138-1146.
- McMurtrie, R.E., Leuning, R., Thompson, W.A., and Wheeler, A.M., 1992. *A Model of Canopy Photosynthesis and Water-Use Incorporating a Mechanistic Formulation of Leaf CO₂ Exchange*. Forest Ecology and Management. 52:261–278.
- Meyer, C.P., 2004. *Establishing a consistent time-series of greenhouse gas emission estimates from savanna burning in Australia*. Final report to the Australian Greenhouse Office, December 2004, CSIRO Division of Atmospheric Research, Aspendale, Victoria, Australia, 58pp.
- 2011. Review of the National Greenhouse Gas Emissions Methodology for Savanna Burning. Report to the Commonwealth Department of Climate Change and Energy Efficiency, 52 p.
 - and Cook G.D., 2011. Seasonality in Greenhouse Gas Emission Factors from Savanna fires. Final Report to NAILSMA, February 2011, CSIRO Marine and Atmospheric Research, Aspendale, Vic, AUSTRALIA, 60 p.
 - and Cook G.D., 2015. Australia's National Greenhouse Gas Inventory 2013: Agriculture. Final Report to the Department of the Environment, CSIRO Oceans and Atmosphere Flagship, Aspendale, Vic, AUSTRALIA.
 - and Cook, G.D., in press. Biomass combustion and emission processes in the northern Australian savannas. Carbon Accounting and Savanna Fire Management, Eds: B.P. Murphy, A.C. Edwards, M. Meyer, and J. Russell-Smith, CSIRO Publishing, Clayton Sth, Victoria, Australia, 2015, pp 73 – 96.
 - Cook G. D., Reisen F., Smith T. E. L., Tattaris M., Russell-Smith J., Maier S. W., Yates C., and Wooster M. J., 2012. *Direct measurements of the seasonality of emission factors from savanna fires in northern Australia*. Journal of Geophysical Research, 117, D20305, doi:10.1029/2012JD017671.
- Micales, J.A., and Skog, K.E., 1996. *The decomposition of forest products in landfills*. International Biodeterioration and Biodegradation, 39 (2-3): pp 145- 158.
- Ministry for the Environment, 2011. Unpublished report to DCCEE, *Review of components of Australia's national inventory system*. New Zealand Government.
- Minson, D.J., and McDonald, C.K., 1987. *Estimating forage intake from the growth of beef cattle*. *Tropical Grasslands*, vol 21, pp 116–122.
- MLA (Meat and Livestock Australia), 2002. *2002 Lamb Survey*. Market Information Services, Meat and Livestock Australia.
- 2012. *National guidelines for beef cattle feedlots in Australia*. 3rd Edn, Meat & Livestock Australia, ML Australia, Sydney, NSW.
- Moe, P.W., and Tyrrell, H.F., 1979. *Methane production in dairy cows*. *Journal of Dairy Science*, vol 62, pp 1583–1586.
- Mohren, G.M.J., and Goldewijk, K.C.G.M., 1990. *CO₂Fix: a dynamic model of the CO₂ fixation in forest stands*. Rapport 624, De Dorschkamp, Research Institute of Forestry and Urban Ecology, Wageningen, 96pp.
- Mokany, K., Raison, R.J., and Prokushkin, A.S., 2006. *Critical analysis of root:shoot ratios in terrestrial biomes*. *Global Change Biology* 12: 84-86
- Moorhead, D.L. and Reynolds, J.F., 1991. *A General Model of Litter Decomposition in the Northern Chihuahuan Desert*. *Ecological Modelling* 59: 197–219.

- Currie, W.S., Rastetter, E.B., Parton, W.J., and Harmon, M.E., 1999. *Climate and Litter Quality Controls on Decomposition: An Analysis of Modelling Approaches*. Global Biogeochemical Cycles 13: 575–589.
- Moss, A.R., 1993. *Methane: Global warming and production by animals*. Chalcombe Publications, Canterbury, UK, 105pp.
- Morgan, K.T., Scholberg, J. M. S., Obreza, T.A., and Wheaton, T. A., 2006. *Size, biomass and nitrogen relationships with sweet orange tree growth*. Journal of the American Society of Horticultural Science, **131** (1), 149-156. Moss, A.R. 1993, 'Methane: Global warming and production by animals'. Chalcombe Publications, Canterbury, UK, 105pp.
- MPIG (Montreal Process Implementation Group for Australia) (2008) 'Australia's State of the Forests Report.' Bureau of Rural Sciences, Canberra. <http://adl.brs.gov.au/forestsaustralia/publications/sofr2008.html>
- 2013, 'Australia's State of the Forests Report 2013', ABARES, Canberra.
- MRT (Mineral Resources Tasmania), 2012. Coal production data, Department of Infrastructure, Energy and Resources, Tasmania. <http://www.mrt.tas.gov.au/>
- Mulholland, J.G., Coombe, J.B., Freer M., and McManus, W.R., 1976. *An Evaluation of Cereal Stubbles for Sheep Production*. Australian Journal of Agricultural Research, 1976, 27, pp 881–893.
- Murphy, B., Rawson, A., Ravenscroft, L. Rankin, M. and Millard, R., 2002. *Paired Site Sampling for Soil Carbon Estimation – NSW*. National Carbon Accounting System Technical Report No. 34, Australian Greenhouse Office, Canberra.
- Murphy, T., Jones, G., Vanclay, J., and Glencross, K., 2013. *Preliminary carbon sequestration modelling for the Australian macadamia industry*. Agroforestry Systems, **87**, 689-698.
- Myers, B.J., Theiveyanathan, S., O'Brien, N.D., and Bond, W.J., 1996. *Growth and water use of Eucalyptus grandis and Pinus radiata plantations irrigated with effluent*. Tree Physiology 16:211-219.
- National Forest Inventory, 1997a. *National Plantation Inventory of Australia*. BRS, Canberra.
- 1997b. *Forecasting of Wood Flows from Australia's Plantations*. A report to the 1997 National Plantation Inventory. Bureau of Resource Sciences, Canberra. 22pp.
- National Greenhouse and Energy Reporting (Audit) Determination 2009 (Cwlth), ComLaw, viewed 9 March 2012, <http://www.comlaw.gov.au/Details/F2010L00053/>
- National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Cwlth), ComLaw, <http://www.comlaw.gov.au/Details/F2011C00469>
- NGGIC (National Greenhouse Gas Inventory Committee), 1995. *The Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks, Workbook for Landfill, Wastewater and Other Waste Activities*, National Greenhouse Gas Inventory Committee Workbook 8.0, Canberra.
- 1996. The Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks, Workbook for Livestock, National Greenhouse Gas Inventory Committee Workbook 6.1, Canberra.
- 2006. *National Inventory Report and Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks: Energy (Fugitive Fuel Emissions)*, Canberra.
- Netherlands Environment Assessment Agency, 2010. *Greenhouse Gas Emissions in the Netherlands 1990-2008, National Inventory Report 2010*, Bilthoven, Netherlands.
- New South Wales Department of Minerals, 1988–94. *New South Wales coal industry profile* (annual), Sydney.
- New Zealand Ministry for the Environment, 2010. *New Zealand's Greenhouse Gas Inventory 1990-2008*, Wellington, New Zealand.

- Nicks, B., Laitat, M., Farnir, F., Vandenheede, M., Desiron, A., Verhaeghe, C., and Canart, C., 2003. *Emissions of ammonia, nitrous oxide, methane, carbon dioxide and water vapour in the raising of weaned pigs on straw-based and sawdust-based deep litters*, Animal Research, vol. 52, pp. 99-107.
- Laitat, M., Farnir, F., Vandenheede, M., Verhaeghe, C., and Canart, C., 2004. *Gaseous emissions in the raising of weaned pigs on fully slatted floor or on straw-based deep litter*. Proceedings of the International Society for Animal Health Hygiene, pp. 69-70.
- NLWRA (National Land and Water Resources Audit), 2001. *Australian Native Vegetation Assessment 2001*, National Land and Water Resources Audit, Canberra.
- Nut Producers Australia (accessed 1 December, 2013). *Australian Pistachio History*. <http://nutproducers.com.au/pistachio-products/australian-pistachio-history/>
- O'Brien, 2006a. *Review of Onsite Industrial Wastewater Treatment*. O'Brien Consulting Greenhouse, Energy, Environment, report to the Australian Government Department of the Environment and Heritage, Canberra.
- 2006b. *Solvent and Clinical Waste Incineration in Australia*, O'Brien Consulting Greenhouse, Energy, Environment, report to the Australian Government Department of the Environment and Heritage, Canberra.
- O'Connell, A.M., 1997. *Decomposition of slash residues in thinned regrowth eucalypt forest in Western Australia*. Journal of Applied Ecology, 34: 111-122.
- OECD (Organisation for Economic and Co-operation Development), 1991. *Estimation of Greenhouse Gas Emissions and Sinks*. Final Report from the OECD Experts Meeting, February 1991 (Revised August 1991), prepared for the IPCC, OECD.
- Oenema, O., Velthof, G.L., Yamulki S., and Jarvis, S.C., 1997. *Nitrous oxide emissions from grazed grassland*. Soil Use and Management, 13, pp 288–295.
- Olives Australia (accessed 1 December, 2013). *About Olive Trees*. http://www.oliveaustralia.com.au/About_Olive_Trees/about_olive_trees.html
- Onesteel, 2009. *2009 Annual Report*. http://www.onesteel.com/images/db_images/annualreports/OneSteel%20Limited%20-%20Annual%20Report%202009.pdf
- Orbital Australia, 2010. *Emissions Factor Derivation from NISE2 Measurements of Vehicles from the Australian Fleet*, internal report to the Department of Climate Change and Energy Efficiency, December 2010.
- 2011a. Literature Review of Uncertainty in Fuel Properties, internal report to the Department of Climate Change and Energy Efficiency, June 2011.
 - 2011b. Preparation of Weighted GHG Results from Additional Data Sources, internal report to the Department of Climate Change and Energy Efficiency, June 2011.
 - 2011c. *Additional Data Analysis for Greenhouse Gas Inventory – Search for Ethanol, LPG and Diesel Deterioration Rate Information*, internal report to the Department of Climate Change and Energy Efficiency, June 2011.
- Palisade Corporation, 2005. *@Risk* Version 4.1. Ithaca, NY, USA.
- 1997. *@Risk for Windows*. Version 3.5.2.
- Parton, W.J., Schimel, D.S., Cole, C.V. and Ojima, D.S., 1987. *Analysis of factors controlling soil organic matter levels in Great Plains grasslands*. Soil Science Society of America Journal. 51:1173–1179.

- Paul, K., Polglase, P., Coops, N., O'Connell, T., Grove, T., Medlam, D., Carlyle, C., May, B., Smethurst, P., and Baillie, C., 2002a. *Modelling Change in Soil Carbon Following Afforestation or Reforestation: Preliminary Simulations Using GRC3 and Sensitivity Analysis*. National Carbon Accounting System Technical Report No. 29 (106pp), Australian Greenhouse Office, Canberra.
- Polglase, P.J., Nyakuengama, J.G. and Khanna, P.K., 2002b. Change in soil carbon following afforestation. *Forest Ecology and Management*. 168: 241–257.
 - Polglase, P.J., and Richards, G.P., 2003a. Sensitivity analysis of predicted change in soil carbon following afforestation. *Ecological Modelling*. 164:137–152.
 - Polglase, P.J., and Richards G.P., 2003b. Predicting Change in Soil Carbon following Afforestation or Reforestation. *Forestry Ecology and Management*, 177: 485–501.
- and Polglase, P.J., 2004a. *Prediction of decomposition of litter under eucalypts and pines using the FullCAM model*. *Forest Ecology and Management*, 191: 73-92.
- and Polglase P.J., 2004b. *Calibration of the Roth C model to turnover of soil carbon under eucalypts and pines*. *Australian Journal of Soil Research*, 42, 883-895.
- S. Roxburgh, J. Raison, J. Larmour, J. England, S. Murphy, J. Norris, P. Ritson, K. Brooksbank, T. Hobbs, C. Neumann, T. Lewis, Z. Read, D. Clifford, L. Kmoch, M. Rooney, D. Freudenberger, J. Jonson, A. Peck, R. Giles, J. Bartle, G. McAurthur, D. Wildy, A. Lindsay, N. Preece, S. Cunningham, T. Powe, J. Carter, R. Bennett, D. Mendham, R. Sudmeyer, B. Rose, D. Butler, L. Cohen, T. Fairman, R. Law, B. Finn, M. Brammar, G. Minchin, P. van Oosterzee and A. Lothian., 2013. *Improved estimation of biomass accumulation by environmental planting and mallee plantings using FullCAM*, report for the Department of the Environment. CSIRO Sustainable Agriculture Flagship, Canberra, Australia.
- Pearson, C.J., Brown, R., Collins, W.J., Archer, K.A., Wood, M.S., Petersen, C., and Bootle, B., 1997. *An Australian temperate pastures database*. *Australian Journal of Agricultural Research*, 48, 453-466.
- Pekol Traffic and Transport, 2013. selected tables purchased from the *Australian Transport Facts*.
- PCI Geomatics, 2000. PCI Geomatics Corporation, USA
- Philippe, F.X., Cabaraux, J.F., and Nicks, B., 2011. *Ammonia emissions from pig houses: Influencing factors and mitigation techniques*. *Agriculture, Ecosystems & Environment*, vol. 141, no. 3-4, pp. 245-260.
- Canart, B., Laitat, M., Wavreille, J., Bartiaux-Thill, N., Nicks, B., and Cabaraux, J.F., 2010. Effects of available surface on gaseous emissions from group-housed gestating sows kept on deep litter, *Animal*, vol. 4, no. 10, pp. 1716-1724.
 - Laitat, M., Canart, B., Vandenheede, M., and Nicks, B., 2007. Comparison of ammonia and greenhouse gas emissions during the fattening of pigs, kept either on fully slatted floor or on deep litter. *Livestock Science*, vol. 111, no. 1-2, pp. 144-152.
 - Laitat, M., Nicks, B., and Cabaraux, J.F., 2012. *Ammonia and greenhouse gas emissions during the fattening of pigs kept on two types of straw floor*. *Agriculture, Ecosystems & Environment*, vol. 150, pp. 45-53.
- Pink, B., 2010. *Australian statistical geography standard (ASGS): Volume 1 – main structure and greater capital city statistical areas*. Australian Bureau of Statistics, Canberra.
- Pitt and Sherry, 2013. *Independent Technical Review of a Proposed Brown Coal Mine Default Fugitive Emissions Factor*. Report for the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education.
- Prince, S.D., Haskett, J., Steininger, M., Strand, H., and Wright, R., 2001. *Net primary production of US Midwest croplands from agricultural harvest yield data*. *Ecological Applications*, 11: 1194-1205.

- Polglase, P.J., Paul, K.I., Khanna, P.K., Nyakuengama, J.G., O'Connell, A.M., Grove, T.S., and Battaglia, M., 2000. *Change in Soil Carbon Following Afforestation and Reforestation*. National Carbon Accounting System Technical Report No. 20 (89pp) Australian Greenhouse Office, Canberra.
- Snowdon, P., Theiveyanathan, T., Paul, K.I., Raison, R.J., Grove, T., and Rance, S.J., 2004. *Calibration of the FullCAM model to Eucalyptus globulus and Pinus radiata and uncertainty analysis*. National Carbon Accounting System Technical Report No. 40, Australian Greenhouse Office, Canberra.
- Potter, C.S., Randerson, J.T., Field, C.B., Matson, P.A., Vitousek, P.M., Mooney, H.A., and Klooster, S.A., 1993. *Terrestrial ecosystem production: a process model based on global satellite and surface data*. *Global Biogeochemical Cycles* 7:811–841.
- Protiviti, 2007. *Review of Management of the National Greenhouse Gas Inventory Database*, internal report to the Department of Environment and Water Resources.
- Punshon, S., and Moore, R. M., 2004. *Nitrous oxide production and consumption in a eutrophic coastal embayment*, *Marine Chemistry*, vol 91(1-4), pp37-51.
- QDNRME (Queensland Department of Natural Resources, Mines and Energy), 1979-2009. *Annual coal statistics*.
- Queensland Transport, 2001. *Transport 2007, An action plan for South East Queensland*, Queensland Transport. http://www.transport.qld.gov.au/Home/Projects_and_initiatives/Plans/Integrated_transport_plans/Transport_2007/
- Queensland Coal Board, 1988–94. *Queensland coal industry annual review* (annual), Brisbane.
- Raison, R.J., Keith, H., Barrett, D., Burrows, W., and Grierson, P.F., 2003. *Spatial Estimates of Biomass in 'Mature' Native Vegetation*. National Carbon Accounting System Technical Report 44, Australian Greenhouse Office, Canberra, Australia, p. 56.
- and Squire, R., 2008. *Forest Management in Australia: Implications for Carbon Budgets*. National Carbon Accounting System Technical Report No 32, Australian Greenhouse Office, Canberra, Australia.
- Raupach, M., Kirby, M., Briggs, P., and Barrett, D. 2000. *Balancing the Australian biosphere: continental budgets of water, carbon, nitrogen and phosphorus*. Project 5.4A. Final report to the National Land and Water Resources Audit, Canberra
- Recycled Organics Unit, University of New South Wales, 2008. *Recycling organics: industry statistics 2007*, Report prepared for Compost Australia by the Recycled Organics Unit. Internet publication www.compostaustralia.com.au and previous issues.
- 2009. *Organics recycling in Australia – Industry statistics 2009*, Recycled Organics Unit, Sydney.
- Redding, M., Devereux, J., Phillips, F., Lewis, R., Naylor, T., Kearton, T., Hill, J.V., and Weidemann, S., in press. *Field measurement of beef pen manure CH₄ and N₂O emissions reveal surprising emission control factors*. *Journal of Environmental Quality*, vol. Submitted for publication 10/4/2014, pp. 31.
- Resource Assessment Commission, 1991. *Forest and Timber Inquiry Draft Report*. Volumes 1 and 2. Commonwealth of Australia, Canberra.
- 1992a. *Forest and Timber Inquiry: Final Report Part I*. Australian Government Publishing Service, Canberra.
 - 1992b. *A survey of Australia's forest resource*. Australian Government Publishing Service, Canberra.
- Richards, G.P., 2002. *Biomass Estimation: Approaches for Assessment of Stocks and Change*. National Carbon Accounting System Technical Report No. 27. Australian Greenhouse Office, Canberra.

- 2001. The FullCAM Carbon Accounting Model: Development, Calibration and Implementation for the National Carbon Accounting System. National Carbon Accounting System Technical Report No. 28 (50pp), Australian Greenhouse Office, Canberra.
- and Brack, C., 2004a. A continental biomass stock and stock change estimation approach for Australia. *Australian Forestry*, 67:284–288.
- and Brack, C., 2004b. A modelled carbon account for Australia's post-1990 plantation estate. *Australian Forestry*, vol 67, no 4, pp289–300 2005.
- and Evans, D., 2004. Development of a carbon accounting model (FullCAM Vers. 1.0) for the Australian continent. *Australian Forestry*, 67:277–283.
- and Evans, D.W., 2000a. CAMFor User Manual v 3.35. National Carbon Accounting System Technical Report No. 26 (47pp), Australian Greenhouse Office, Canberra.
- and Evans, D.W., 2000b. CAMAg National Carbon Accounting System (electronic model) Australian Greenhouse Office, Canberra.
- and Evans, D.W., 2000c. GRC3 National Carbon Accounting System (electronic model) Australian Greenhouse Office, Canberra.
- Borough, C., Evans, D., Reddin, A., Ximenes, F. and Gardner, D., 2007. *Developing a carbon stocks and flows model for Australian wood products*. *Australian Forestry*, 70 (2): 108-119.

Rio Tinto, 2009. *2009 Annual report*. <http://www.riotinto.com/annualreport2009/production/metals.html>

Robinson, D.W., and Kirkby, C.A., 2002. *Maize stubble management survey: summary of results*. CSIRO Land and Water Technical Report 13/02, CSIRO Land and Water.

Rotz, C.A., 2004. *Management to reduce nitrogen losses in animal production*. *Journal Animal Science*, vol. 82 , pp. 119-137.

Ruimey, A., Saugier, B., and Dedieu, G., 1994. *Methodology for the estimation of terrestrial net primary production from remotely sensed data*. *Journal of Geophysical Research*, 99:5263–5283.

Russell-Smith, J., Lucas, D., Gapindi, M., Gunbunuka, B., Kapiirigi, N., Namingum, G., Lucas, K., Giuliani, P., Chaloupka, G., 1997. *Aboriginal resource utilization and fire management practice in western Arnhem Land, monsoonal northern Australia: notes for prehistory and lessons for the future*. *Human Ecology*, 25, 159–195. doi:10.1023/A:1021970021670.

- Edwards, A.C., Cook, G.D., Brocklehurst, P., and Schatz, J., 2004. Improving greenhouse emissions estimates associated with savanna burning northern Australia: Phase 1. Final Report to the Australian Greenhouse Office, June 2004, 27 pp.
- Murphy, B.P., Meyer, C.P., Cook G.D., Maier S., Edwards A.C., Schatz J., and Brocklehurst, 2009. Improving estimates of savanna burning emissions for greenhouse accounting in northern Australia: limitations, challenges, applications. *International Journal of Wildland Fire*, 18(1), pp1-18.
- Yates, C.P., Edwards, A.C., Evans, J., and Lynch, D., in press. *Lower rainfall methodology application*. Carbon Accounting and Savanna Fire Management, Editors: B.P. Murphy, A.C. Edwards, M. Meyer and J. Russell-Smith, CSIRO Publishing, Clayton Sth, Victoria, Australia, pp 115 – 128.

Ryan, M.G., Binkley, D., and Fownes, J.H., 1997. *Age-related decline in forest productivity: pattern and process*. *Advances in Ecological Research*, 27: 213-262.

Ryan, W.G., and Samarin, A., 1992. *Australian Concrete Technology*, Longman Cheshire, Melbourne.

Sanderman, J., Farquharson, R., and Baldock, J., 2009. *Soil carbon sequestration potential: a review for Australian agriculture*. Report for the CSIRO National Research Flagships Sustainable Agriculture.

- Sanfelipe Olives, accessed 1 December, 2013. *Olive the Facts*. <http://www.sanfelipeoliveco.com/facts.html>
- SCA (Standing Committee on Agriculture), 1990. *Feeding standards for Australian livestock, Ruminants*. SCA Ruminant Sub-Committee, CSIRO Australia.
- Scherbak, I., Grace, P., Macdonald, B., Scheer, C., and Rowlings, D., 2014. *Determination of emission factors for estimating nitrous oxide emissions from Australia's cotton industry*, Report to the Department of the Environment.
- and Grace, P., 2014. *Determination of emission factors for estimating fertiliser-induced nitrous oxide emissions from Australia's rural production systems*. Report to the Department of the Environment.
- Shorten, P.R., and Redding, M.R., submitted. *Models fitted to manure emissions contract with inventory*. Journal of Environmental Quality, Submitted for publication 30/5/2014, pp. 32.
- Schlamadinger, B., Canella, L., Marland, G. and Spitzer, J., 1997. *Bioenergy strategies and the global carbon cycle*. Sciences Geologiques, 50:157–182.
- Schwenke, G., Haigh, B., McMullen, G., and Herridge, D., 2010. *Soil nitrous oxide emissions under dryland N-fertilised canola and N₂-fixing chickpea in the northern grains regions, Australia*. 19th World Congress of Soil Science, Soil Solutions for a Changing World, 1 – 6 August 2010, Brisbane, Australia, pp228-231.
- Sheriff, D.W., Mattay, J.P., and McMurtrie, R.E., 1996. *Modeling productivity and transpiration of Pinus radiata: climatic effects*. Tree Physiology, 16: 183-186.
- Skjemstad, J., and Spouncer, L., 2002. *Estimating Changes in Soil Carbon Resulting from Changes in Land Use*. National Carbon Accounting System Technical Report No. 36, Australian Greenhouse Office, Canberra.
- and Spouncer, L., 2003. Integrated Soils Modelling for the National Carbon Accounting System. National Carbon Accounting System Technical Report No. 36, Australian Greenhouse Office, Canberra, Australia.
 - Spouncer, L.R., and Beech, T.A., 2000. Carbon Conversion Factors for Historical Soil Carbon Data. National Carbon Accounting System Technical Report No. 15 (17pp). Australian Greenhouse Office, Canberra.
 - Spouncer, L.R., Cowie, B. and Swift, R.S., 2004. Calibration of the Rothamsted organic carbon turnover model (*RothC ver. 26.3*), using measurable soil organic carbon pools. Australian Journal of Soil Research (2004), 42, 79-88.
- Snowdon, P., 2002. *Modeling Type 1 and Type 2 growth responses in plantations after application of fertilizer or other silvicultural treatments*. Forest Ecology and Management, 163: 229-244.
- Eamus, D., Gibbons, P., Khanna, P.K., Keith, H., Raison, R.J., and Kirschbaum, M.U.F., 2000. Synthesis of allometrics, review of root biomass, and design of future woody biomass sampling strategies. National Carbon Accounting System Technical Report No. 17 (142pp). Australian Greenhouse Office.
 - Raison, J., Keith, H., Ritson, P., Grierson, P., Adams, M., Montagu, K., Bi, H., Burrows, W., and Eamus, D., 2002. *Protocol for Sampling Tree and Stand Biomass*. National Carbon Accounting System Technical Report No. 31 (72pp), Australian Greenhouse Office, Canberra.
 - Ryan, P., and Raison, J., 2005. *Review of C:N Ratios in Vegetation, Litter and Soil under Australian Native Forests and Plantations*. National Carbon Accounting System Technical Report No. 45 (60pp), Australian Greenhouse Office, Canberra.
- and Waring, H.D., 1984. *Long-term nature of growth responses obtained to fertilizer and weed control applied at planting and their consequences for forest management*. Grey, D.C., Shonau, A.P.G., Shutz, C.J. (Eds.), Proceedings of the IUFRO Symposium on Site and Productivity of Fast Growing Plantations, 30 April to 11 May, Pretoria and Pietermaritzberg, South Africa. Forest Research Institute, Pretoria, pp 701-711.

- and James, R., 2008. *Historical development of silvicultural practices in plantations*. Raison, R.J. and Squire, R. (Eds.), Forest management in Australia: Implications for carbon budgets. National Carbon Accounting System Technical Report No. 32, Australian Greenhouse Office, Canberra, Australia.
- Spencer, R., Keenan, R., Ranatunga, K., and Wood, M., 2001. *Plantation Projections in Australia*. (unpublished report).
- Stewart, J.B., Smart, R.V., Barry, S.C., and Veitch, S.M., 2001. *1996/97 Land Use of Australia – Final Report for Project BRR5*. National Land and Water Resources Audit, Canberra.
- Swift, R., and Skjemstad, J., 2002. *Agricultural Land Use and Management Information*. National Carbon Accounting System Technical Report No. 13 (446pp). Australian Greenhouse Office, Canberra.
- Sydney Water, last accessed April 2015. *Wastewater network map*. <http://www.sydneywater.com.au/SW/water-the-environment/how-we-manage-sydney-s-water/wastewater-network/index.htm>
- Thackway, R., and Cresswell, I.D., 1995. *An Interim Biogeographic Regionalisation for Australia: a framework for establishing the national system of reserves*. Version 4.0. Australian Nature Conservation Agency, Canberra.
- Thomson, S., 2010. *Gas layering in the subsurface: Implications for greenhouse gas emissions, Proceedings of the 37th symposium on the geology of the Sydney basin*. Hunter Valley, May 6-7, 2010.
- Todd, J., Gibbons, A., King, R., and Kinrade, P., 1989a. *Measurement of Air Pollutants from Woodheaters*. NERDP Project Number 1186, Centre for Environmental Studies, University of Tasmania, Hobart.
- Gray, K.M., and King L.R., 1989b. National Fuelwood Study, the Commissioned Study on Fuelwood Use and Supply in Australia. Department of Primary Industries and Energy, Canberra.
 - 1991. Emissions and Performance of Woodheaters When Burning Softwoods. Fuelwood Report No. 3; Centre for Environmental Studies, University of Tasmania, Hobart.
 - 1993. Carbon dioxide emissions from firewood combustion. Inhouse Fuelwood Report No. 55, Centre for Environmental Studies, University of Tasmania.
 - 2001. Factors Influencing Residential Wood-Smoke Emissions: Hobart Survey. Report for the Department of Primary Industries, Water and Environment, Hobart, January 2001.
 - 2003. Estimating Greenhouse Gas Emissions from Residential Firewood Use Australia 1989/95 to 2000/01. Report for Energy Strategies Pty Ltd and the Australian Greenhouse Office, Eco-Energy Options.
 - 2005. Carbon dioxide emissions from firewood combustion. Unpublished report to the Australian Greenhouse Office.
 - 2008. *Woodheater Operation and Firewood Parameters: Australia*. Prepared for the Department of the Environment and Water Resources, EEO Report 08/01.
 - 2011. *Estimating Greenhouse Gas Emissions from Residential Firewood Use: Australia 1989/90 to 2010/11*. Eco-Energy Options Pty Ltd.
- Tolhurst, K.G., 1994. *Assessment of Biomass Burning in Australia: 1983 to 1992. Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks, Agriculture, Workbook for Non-Carbon Dioxide Gases from the Biosphere*. National Greenhouse Gas Inventory Committee, Workbook 5.0 1994.
- Tothill, J.C., and Gillies, C., 1992. *The pasture lands of northern Australia. Their condition, productivity and sustainability*. Report to Meat Research Corporation. Tropical Grassland Society of Australia Occasional Publication No.5. St Lucia, Queensland. 115 pp.
- Treadrea, P., 1995. *The Environmental Consequences of Urban and Rural Bituminous Practices*. Australian Road Research Board Transport Research (ARRBTR), Melbourne.

- Tsaranu, M., 2007. *Report of quality assurance review of the Australia's National Greenhouse Gas Inventory 2006: Industrial Processes Sector*. Report to the Australian Greenhouse Office.
- Tucker, R.W., Lott, S.C., Watts, P.J. and Jukes, P.D., 1991. *Lot feeding in Australia – a survey of the Australian lot feeding industry*. Information Series QI91019, Department of Primary Industries, Brisbane.
- McGahan, E., Galloway, J.L., and O'Keefe, M.F., 2010. *National environmental guidelines for piggeries – Second Edition*, APL Project 1832, Australian Pork Ltd, Deakin.
- Turner, B., 1984. *Potential productivity gains in Australian east coast Pinus radiata plantations*. Grey, D.C., Shonau, A.P.G., Shutz, C.J. (Eds.), Proceedings of the IUFRO Symposium on Site and Productivity of Fast Growing Plantations, April 30-May 11, Pretoria and Pietermaritzberg, South Africa. Forest Research Institute, Pretoria, pp 947-956.
- and James, R., 1997. *Forecasting of wood flows from Australia's plantations – a report to the 1997 National Plantation Inventory*. Bureau of Rural Sciences, Canberra, Australia.
- and James, R., 2002. *Derivation of indicative yields for major plantation species*. In: Richards, G. (Ed) Biomass Estimation: Approaches for Assessment of Stocks and Change. National Carbon Accounting System Technical Report no. 27, Australian Greenhouse Office, Canberra, pp 71-77.
- Lambert, M.J., Hopmans, P., and McGrath, J., 2001. *Site variation in Pinus radiata plantations and implications for site specific management*. New Forests 21: 249-282.
- Unkovich, M., Baldock, J., and Marvanek, S., 2009. *Which crops should be included in a carbon accounting system for Australian agriculture?* Crop and Pasture Science 60: 617-626.
- Baldock, J. A., and Farquharsan R., 2014. *Estimating historical crop yields on a regional scale using a simple water-driven productivity model*. CSIRO publications, Australia (In Prep.)
- Baldock, J., and Forbes, M., 2006. *Australian crop yields and harvest Indices (Microsoft Access Database)*. CSIRO Land and Water, Adelaide.
- Baldock, J., and Forbes, M., 2010. *Variability in harvest index of grain crops and potential significance for carbon accounting: examples from Australian agriculture*. Advances in Agronomy 105: 173-219.
- USEPA (United States Environment Protection Agency), 1985. *Compilation of Air Pollutant Emission Factors*, Vol 1, Stationary Point and Area Sources, Fourth Edition, Research Triangle Park, North, USA.
- 1989. *Compilation and Speciation of National Emissions Factors for Consumer/Commercial Solvent Use*. EPA-450/2-89-008.
 - 1991a. Nonroad Engine and Vehicle Emission Study – Report. Office of Air and Radiation, USEPA, Washington, DC.
 - 1991b. Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone. Volume 1: General Guidance for Stationary Sources. EPA-450/4-91-016. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.
 - 1992. Procedures for Emission Inventory Preparation, Vol IV: Mobile Sources. Research Triangle Park, North Carolina, USA.
 - 1995a. Highway Vehicle Emission Estimates – II. Office of Mobile Sources, USEPA, Research Triangle Park, , North Carolina, USA.
 - 1995b. of Air Pollutant Emission Factors, Vol 1, Stationary Point and Area Sources. Fifth Edition, Research Triangle Park, NC, USA.
 - 1996. AP-42 Compilation of Air Pollutant Emission Factors Vol 1 Stationary Point and Area Sources. United States Environmental Protection Agency, available at www.epa.gov/ttn/chief/index.html

- 1997. Emission Inventory Improvement Program, Document Series Volume 3 – Chapter 6, <http://www.epa.gov/ttn/chief/eiip/techreport/volume03/index.html>
 - 2005b. *Compilation of Air Pollutant Emission Factors, Vol 1, Stationary Point and Area Sources*. Fifth Edition, Research Triangle Park, NC, USA.
- van Sliedregt, H., McGahan, E., and Casey, K., 2000. *Predicting Waste Production From Feedlot Cattle*. Unpublished Confidential Report prepared for Cattle and Beef CRC (Meat Quality) Sub-Program 6 – Feedlot Waste Management, DPI Intensive Livestock Environmental Management Services, Toowoomba, Qld.
- Vic Forests (Victoria Forests), 2008. *Vic Forests: Annual Report 2008*. Victoria, Australia.
- VicHealth, 1999. *Moving to Healthier People and Healthier Places – Trends in Transportation*. Victorian Health Promotion Foundation. <http://www.vichealth.vic.gov.au/assets/contentFiles/vhtransch3.pdf>
- Villalobos, F. J., Testi, L., Hidalgo, J., Pastor, M., and Orgaz, F., 2006. *Modelling potential growth and yield of olive (Olea europaea L.) canopies*. European Journal of Agronomy, **24**, 296-303.
- Viscarra Rossel, R.A., and Webster, R., 2012. *Predicting soil properties from the Australian soil visible-near infrared spectroscopic database*. European Journal of Soil Science, vol. 63, no. 6, pp. 848-60.
- Bui, E.N., and Baldock, J.A., 2014. Spatial estimates of organic carbon storage to support national carbon accounting and monitoring under climate change. *Global Change Biology*, 20(9):2953-2970.
 - R.A., Chen, H., and Hicks, W., 2015. Prediction of spatial distribution of soil attributes to depth from Australian site and covariate data. *Soil Research*, in preparation.
 - Chen, C., Grundy, M., Searle, R., Clifford, D., and Campbell, P.H., 2015. The Australian three-dimensional *soil grid: Australia's contribution to the GlobalSoilMap project*. *Soil Research*, in preparation.
- Vinyl Council Australia website, last accessed April 2015. *PVC Safe Manufacturing > Manufacturing Process*. <http://www.vinyl.org.au/pvc-safe-manufacturing/manufacturing-process>
- WA Department of Industry and Resources, 2006. *Petroleum Guidelines, Drilling Fluids Management*. Environment Division, Perth.
- Walcott J., Zuo, H., Loch, A., Smart, R., 2013. *Patterns and trends in Australian agriculture: a consistent set of agricultural statistics at small areas for analysing regional change*. *Journal of Land Use Science*.
- Walkley, A., and Black, I. A., 1934. *An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method*. *Soil Science*. 37: 29–38.
- Wang, X. J., Smethurst, P. J., and Herbert, A. M., 1996. *Relationships between three measures of organic matter or carbon in soils of eucalypt plantations in Tasmania*. *Australian Journal of Soil Research*. 34, 545 – 553.
- Waterworth, R.M., Brookhouse, M.T., Kesteven, J., 2005. *Use of tree ring data to test a broad-scale model of forest productivity in Australia*. Innes, J.L., Edwards, I.K., Wilford, D.J. (Eds.), IUFRO 2005. The International Forestry Review, Brisbane, Australia, p. 76.
- Richards, G.P., Brack, C.L. and Evans, D.M.W., 2007. *A generalised process-empirical hybrid model for predicting forest growth*. *Forest Ecology and Management* 238, 231-243.
 - and Richards, G.P., 2008. *Implementing Australian forest management practices into a full carbon accounting model*. *Forest Ecology and Management* 255: 2434-2443.

- Watson, I.W., McKeon, G.M., Wilcox, D.G., 2004. *Modelling climate and management effects on shrub populations in the Gascoyne region of Western Australia and the north east district of South Australia*. Pasture degradation and recovery in Australia's rangelands. Eds: G. McKeon, W. Hall, B. Henry, G. Stone and I. Watson. Department of Natural Resources, Mines and Energy, Queensland, Australia.
- Watts, P., McGahan, E., Bonner, S.L., and Wiedemann, S., 2012. *Feedlot Mass Balance and Greenhouse Gas Emissions – A Literature Review*. Final Report, Project B.FLT.0361, Meat & Livestock Australia, Sydney, Australia.
- Watts, P.J., and Tucker, R.W., 1994. *Designing Better Feedlots*, Conference and Workshop Series QC94002, Department of Primary Industries, Brisbane, Queensland.
- WBCSD (World Business Council for Sustainable Development), 2005. *The Cement CO₂ Protocol, CO₂ accounting and Reporting Standard for the Cement Industry*. Cement Sustainability Initiative, Climate Protection Task Force, Protocol Guidance Document Version 2.0.
- Webb, A., 2002. *Pre-clearing soil carbon levels in Australia*. National Carbon Accounting System Technical Report No. 12 (204pp). Australian Greenhouse Office.
- Webbnet Land Resource Services Pty. Ltd., 2000. *Estimation of Changes in Soil Carbon Due to Changed Land Use*. National Carbon Accounting System Technical Report No. 2 (92pp) Australian Greenhouse Office, Canberra.
- Weeks, I.A., Galbally, I.E., Guo-hong, H. 1993, *Nitrous Oxide Emissions from Motor Vehicles in Australia*. Research Report to ANZECC, Final Report, CSIRO, Victoria.
- West, P.W., and Mattay, J.P., 1993. *Yield prediction models and comparative growth rates for 6 eucalypt species*. Australian Forestry 56(3): 211–225.
- Wiedemann, S., McGahan, E., and Murphy, C., 2012. *Energy, Water and Greenhouse Gas Emissions in Australian Pork Supply Chains: A Life Cycle Assessment*, Pork Co-operative Research Centre, Adelaide, SA.
- Sullivan, T., and McGahan, E.J., 2014. *GHG Prediction methods for feedlots, poultry and pigs*. Technical report for the Department of Environment Greenhouse Gas Inventory Team, FSA Consulting Report 8199/1.
- White, D.H., Bowman, P.J., Morley, F.H.W., McManus, W.R., and Filan, S.J., 1983. *A simulation model of a breeding ewe flock*. *Agricultural Systems*, vol 10 pp 149–189.
- 2002. *A check of the internal consistency of pasture and livestock data used to estimate levels of greenhouse gas emissions from the sheep and beef cattle industries*. Unpublished report to the Australian Greenhouse Office and CSIRO Sustainable Ecosystems, ASIT Consulting.
- Whittemore, C., 1993. *Energy value of feedstuffs for pigs*. *The Science and Practice of Pig Production*. Longmans Scientific and Technical Publications, USA.
- Williams D.J., 1993. *Methane emissions from the manure of free-range dairy cows*. *Chemosphere*, vol. 26, pp. 179–187.
- Williams, D.J., Saghafi A., Lange A., and Drummond, M.S., 1993. *Methane emissions from open-cut mines and post-mining emissions from underground coal*. CSIRO Investigation report CET/IR173.
- Lama, R.D., and Saghafi, A., 1996. *Methane Emissions from Coal Mining*. International Energy Agency, Paris.
- Williams, Y. and Wright, A., 2005. *Variation in methane output between sheep*. Abstracts *Greenhouse 2005: Action on Climate Change*, Melbourne, Victoria, 13–17 November 2005. CSIRO, Australia, pg 110.

- WMAA (Waste Management Association of Australia), 2007. *National landfill survey results*.
<http://www.wmaa.asn.au/uploads/documents/State%20Summary%20June%202007.pdf>
- Woldendorp, G., and Keenan, R.J., 2005. *Coarse woody debris in Australian forest ecosystems: A review*. *Austral Ecology* 30: 834-843.
- WSAA (Water Services Association of Australia), 2005. *Facts 2005 – The Australian Urban Water Industry*, Melbourne.
- 2011. *National Greenhouse and Energy Reporting System – Guidelines for the Water Industry*. Draft.
- Wu, X., Furby, S., and Wallace, J., 2004. *An Approach for Terrain Illumination Correction*. In The 12th Australasian Remote Sensing and Photogrammetry Conference Proceedings, Fremantle, Western Australia, 18–22 October.
- Yamulki, S., and Jarvis, S.C., 1997. *Nitrous oxide emissions from excreta from a simulated grazing pattern and fertiliser application to grassland*. *Gaseous emissions from grasslands*, eds: S.C. Jarvis and B.F. Pain, CAB International, Wallingford, UK, pp 195–199.
- Yates, C.P., Russell-Smith, J., Murphy, B.P., Desailly, M., Evans, J., Legge, S., Lewis, F., Lynch, D., and Edwards, A.C., in press. *Fuel accumulation, consumption and fire patchiness in the lower rainfall savanna region*. *Carbon Accounting and Savanna Fire Management*, eds: B.P. Murphy, A.C. Edwards, M. Meyer and J. Russell-Smith, CSIRO Publishing, Clayton Sth, Victoria, Australia, pp 115 – 128.
- Ximenes, F., and Gardner, D., 2005. *Recovery of Biomass as Green Sawn Boards after Milling of Spotted Gum (Corymbia maculata) Sawlogs from NSW South Coast Forests*. National Carbon Accounting System Technical Report No. 48, Australian Greenhouse Office, Canberra, Australia.
- Gardner, D., and Marchant, J., 2005. *Total biomass measurement and recovery of biomass in log products in Spotted Gum (Corymbia maculata) forests of SE NSW*. National Carbon Accounting System Technical Report No. 47, Australian Greenhouse Office, Canberra.
 - Gardner, D., and Richards, G.P., 2006. *Total above-ground biomass and biomass in commercial logs following the harvest of Spotted Gum (Corymbia maculata) forests of SE NSW*. *Australian Forestry*, 69: 213-222.
- Gardner, W.D., and Kathuria, A., 2008a. *Proportion of aboveground biomass in commercial logs and residues following the harvest of five commercial forest species in Australia*. *Forest Ecology and Management*, 256: 335-346.
- Gardner, W.D., and Cowie, A.L., 2008b. *The decomposition of wood products in landfills in Sydney, Australia*. *Waste Management*, 2008, doi:10.1016/j.wasman.2007.11.006.
- Zhang, G., Zhang, J., Ren, J., Li, J. and Liu, S., 2008. *Distributions and sea-to-air fluxes of methane and nitrous oxide in the North East China Sea in Summer*. *Mar. Chem.* 110: 42-55.

environment.gov.au

