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Carbon storage in wood products in Australia: a review of the current state of knowledge

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Carbon storage in wood products in Australia:
a review of the current state of knowledge

Prepared for the

**Forest & Wood Products
Research & Development Corporation**

by

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Executive Summary

Several overseas studies have acknowledged that wood products can significantly extend the carbon sequestration benefits provided by forests. In Australia, the most relevant work has been undertaken through the Cooperative Research Centre for Greenhouse Accounting (CRCGA) and the development of a national model by the Australian Greenhouse Office (AGO) to account for carbon in wood products. Although it is often claimed by the forest industry in Australia that the use of wood is the best choice for the environment, few scientifically relevant data have been developed here to support these claims.

Issues, important to Australia and directly linked to the carbon storage benefits provided by wood products, have arisen recently:

a) Current carbon trading schemes do not acknowledge any continuing carbon storage in wood products. The inclusion of wood products in carbon trading schemes would make carbon trading a more attractive proposition for those in forestry or wood and wood products industries. Some of the main implications would be an immediate increase in the revenues from carbon sequestration and further incentive for establishment of forests for carbon sequestration. There is also potential for changing two of the current requirements for recognition of carbon sequestration under the NSW Greenhouse Gas Abatement Scheme: the need for forests used for carbon sequestration to be in previously cleared lands; and the requirement that the carbon be stored for 100 years in the trees, rather than recognising carbon storage in wood products. Those requirements constitute a major barrier to the development of more carbon sequestration projects.

b) None of the current energy rating schemes that guide the use of construction materials takes into account carbon storage in wood products, resulting in a significant competitive disadvantage for wood products. Wood products are also disadvantaged when life cycle assessments (LCA) are performed to compare the environmental credentials of materials, as carbon storage in wood products is currently not recognised in these assessments, either.

c) The choice of disposal option of wood products has a direct impact on the overall environmental performance of the product. Most wood products in Australia are placed in landfills at the end of their lives. The assumed decomposition rates are critical, as carbon dioxide and, most importantly, methane (a very powerful greenhouse gas) are generated through the decomposition process. The higher the decay rate, the more methane is produced and the less environmentally friendly the product becomes, when the whole of life impacts of the products are considered.

In Australia, the main aim of the CRCGA *Carbon in Wood Products* Project was to develop data, methodologies and a model (*TimberCAM*) to underpin a carbon accounting system and a carbon trading scheme in harvested wood products. Research from this project has revealed that wood products in landfill decompose only to a minimal extent. A model (*TimberCAM*) was developed to track the fate of carbon in wood products, and a method for estimating the amount of carbon stored in wood products was proposed. The AGO commissioned the development of modelling work

to determine the carbon stocks in wood products for the *National Carbon Accounting System*. Under the most recent modelling development, wood products are assigned to young, medium and old age-pools, and materials leaving service may be used for bioenergy, placed in landfills, recycled or emitted to the atmosphere.

Internationally, the main focus of the research has been on the development of carbon storage factors with emphasis on products in landfills (USA), and the development of modelling techniques for estimating carbon storage in wood products (Europe). The Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention for Climate Change (UNFCCC) are the main bodies responsible for coordinating the development of methods and approaches to account for carbon in national greenhouse gas inventories. There are five main approaches under consideration, which vary by their treatment of traded wood products. The default approach does not acknowledge any long-term storage in wood products.

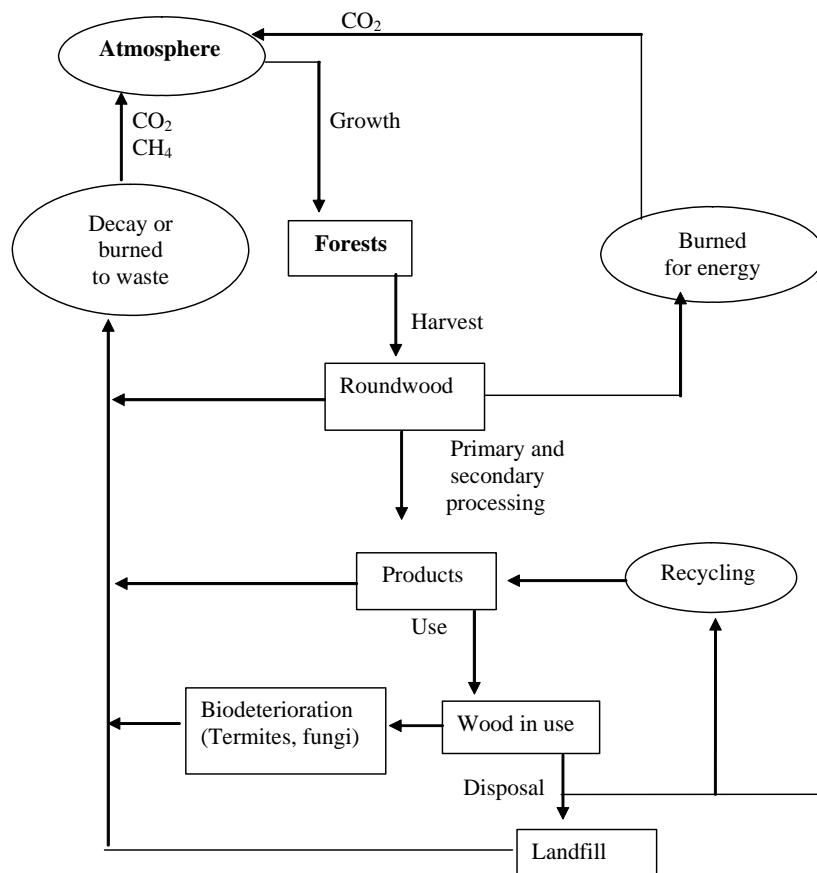
Suggested research priorities include the development of carbon storage factors (including refinement of carbon stocks in housing) and an energy budget for the main types of wood products, which are essential as an input to energy rating systems and LCAs. Further work to confirm preliminary findings of minimal decomposition of wood products in landfills is required, as well as the development of a LCA of the alternative disposal options for those products. The proposed research is important to demonstrate further the environmental credentials of wood products in Australia and to optimise the benefits from carbon sequestration.

Introduction

The planting of forests is an effective way to reduce the quantity of carbon (C) dioxide in the atmosphere. It has been increasingly acknowledged that wood products can significantly extend the carbon sequestration benefits provided by forests (Skog and Nicholson 1998; UNFCCC 2003). Winjum *et al.* (1998) estimated that the pool of wood products (including solid wood, reconstituted wood panels and paper) may be increasing globally by about 140 million tonnes (Mt) / year. Nabuurs *et al.* (1997) estimated that the total carbon in wood products in Europe is equivalent to about 30% of the total carbon in the European forests. However, those studies did not include the potential long-term storage of C in wood products in landfills in their estimates. In the USA, the estimated C in wood products in landfills is equivalent to the total carbon stored in wood products in service (US EPA 2004).

The key focus in the area of C research in Australia has been in quantifying the benefits of C sequestration in forests. However, each year 25 million m³ of logs are removed from Australian forests, the equivalent of approximately 8 million tonnes of C or about 30 million tonnes of carbon dioxide equivalents. Depending on the type of product manufactured and on how it is disposed of at the end of its life, the C will remain “locked up” in the product for many decades (Figure 1).

Figure 1. Life cycle of carbon in wood products



The proportion of the C in the logs that ends up in finished products and residues depends on various factors such as species, site conditions, harvesting technique, log grading and efficiency of conversion.

Currently, only four countries (Australia, Canada, United Kingdom and USA) report estimates of C stored in wood products in their national greenhouse gas inventories (UNFCCC 2005). Carbon in wood products is excluded from accounting during the first commitment period (2008-2012) of the *Kyoto Protocol* (KP). The Intergovernmental Panel on Climate Change (IPCC) Guidelines suggest a default approach for accounting for carbon in wood products that “all C removed in wood and other biomass from forests is emitted in the year of harvest” (IPCC 1997 Vol 3 p5.17), based on the assumption that stocks of wood products are not increasing significantly. However, this is an over-simplification, and the IPCC Guidelines allow reporting of C storage in wood products in national inventories if it is demonstrated that the stocks of wood products are increasing.

Despite increasing acknowledgment of the significant role wood products play in extending C storage following the harvest of trees, existing C trading schemes do not yet provide mechanisms to allow the inclusion of wood products.

This report provides a brief account of the state of knowledge of C storage in wood products in Australia, with emphasis on the built environment and waste disposal, as the majority of the sawn and panel products manufactured in Australia are used in residential buildings and disposed of in landfills (Gardner *et al.* 2004). It briefly describes international developments in the area and discusses the schemes and rules for carbon trading with relevance to wood products. The report aims to identify the key interested parties, key policy issues and recommendations on future R&D directions for this important area of research.

State of Knowledge

This section describes the most important identified research and publications related to carbon storage in wood products in Australia and internationally.

Australia

Research into the C storage in wood products in Australia has largely been limited to the research project by the Cooperative Research Centre for Greenhouse Accounting (CRCGA), as part of the *Carbon in Wood Products* project, and work commissioned by the Australian Greenhouse Office (AGO) as part of the *National Carbon Accounting System* (NCAS). The focus of previous studies in the area was generally on the development of data for embodied energy and life cycle assessment (LCA) comparisons (eg Hill 1978; Lawson 1995; McCoubrie and Treloar 1996; Higham and Todd 1998; Pullen 2000; Treloar 2000; Treloar *et al.* 2001; Glover *et al.* 2002). Very few studies go beyond a literature review of the topic. The only other current research in the area has been carried out by a PhD student at Melbourne University. A description of the relevant work is given below.

Cooperative Research Centre for Greenhouse Accounting (CRCGA)

The fate of C in wood products in Australia (excluding paper) was studied using a LCA approach. The stated main aim of the project was to develop data, methodologies and a model (*TimberCAM*) to underpin a C accounting system and a C trading scheme in harvested wood products. A number of field studies have been conducted to identify the fate of C in important commercial forest tree species following their harvest, milling, conversion to wood products and disposal at the end of their service life. The sawmill recovery studies demonstrated the recovery to products may vary significantly according to the tree species. The recovery of green rough sawn boards after processing of blackbutt, messmate and spotted gum sawlogs was 42%, 46% and 51%, respectively, of the sawlog weight. The default figure used by Jaakko Pöyry (38%, 1999) significantly underestimates the recovery, and leads to overestimations of the volume of residues produced. The recoveries to dried and dressed boards following processing of sawn kiln-dried hardwood boards ranged from 72% for messmate to 76% for blackbutt, which were again considerably higher than the default value provided by Jaakko Pöyry (68%, 1999). For radiata pine, the recoveries to green sawn and dried dressed boards were 62% and 75%, respectively, compared to 54% and 84% respectively suggested by Jaakko Pöyry (1999).

C storage in the built environment

Waste audits were conducted on construction of a single-storey house and a two-storey house in western Sydney. The results indicated that approximately 8 per cent of the wood products that were delivered to the construction site were wasted. This is despite the wall and roof framing being delivered prefabricated. These results were used in a LCA study to find out the greenhouse gas implications of substituting wood products for alternative materials in house construction. A range of alternative materials used in the main building components was assessed (eg concrete slab and timber sub-frame, timber and steel wall framing, aluminium and timber windows). The results showed that the use of wood products can reduce the emissions of greenhouse gases associated with house construction. More than 25 tonnes of CO₂-equivalents would be saved if the house was built primarily using wood products (*InWood International* 2004). However,

the results did not include the greenhouse gas implications of the insulation type used, maintenance and product service lives.

A web-based survey was conducted to obtain data on the use and service life of wood products in residential buildings in Australia. More than 1,000 responses were received from home owners across Australia. The median age of replacement of a number of building components made of wood products is included in Table 1.

Table 1. Median age of replacement of wood products in residential housing in Australia

House component	Median age of replacement (years)
Kitchen furniture	25
Windows	40
Decks	16
Fences	25
House	44

Waste disposal

The AGO (2004) estimates that 2.5 million tonnes of wood products are placed in landfills in Australia each year. Excavations were conducted in three landfill sites where wood products had been buried for 19, 29 and 46 years. The chemical analysis of the wood products revealed that only up to 3.5 % of the C in wood products was lost through decomposition (Gardner *et al.* 2002). This is much lower than assumptions based on experiments conducted under optimised conditions in the laboratory. Some of the implications of this finding include:

- Larger quantities of C are retained in long-term storage than previously thought;
- The environmental footprint for wood products is lighter than previously thought, with implications for LCAs that include disposal of wood products in their scope;
- The importance of service life in the assessment of the C storage potential of different products is decreased, as the C will be stored for many decades in wood products in landfills; and
- Estimates of national greenhouse gas emissions are lower

Carbon accounting tools

A C accounting model for wood products – *TimberCAM* (Figure 1) was developed, accounting for the fate of C sequestered in trees through their harvesting, conversion to wood products, use and end-of-life options; reuse, recycling or disposal (Ximenes and Davies 2004). The main application of the model is at a project level to support carbon trading schemes.

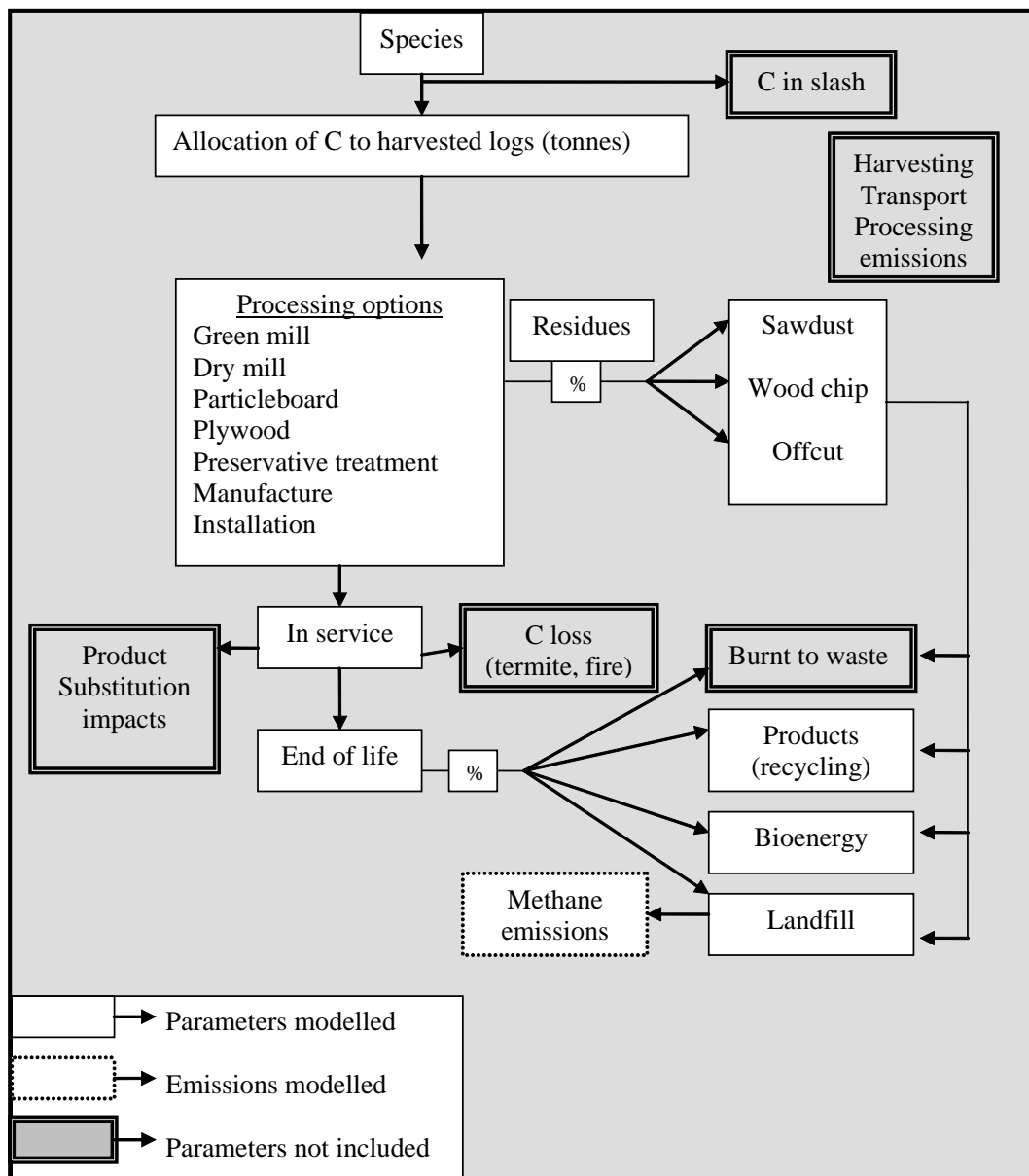
Most methods currently proposed internationally to account for carbon in wood products are unnecessarily complicated. A simpler method to estimate the proportion of C retained in long-term storage in wood products has been proposed in this project (Gardner *et al.* 2004). The method, based on one equation, takes into account long-term

storage in landfills and recognises avoided fossil C use due to use of wood products or residues for energy. The proportion of harvested C that will be stored long-term in the wood products pool is a function of:

- the proportion of residues associated with processing round, sawn and panel products from logs;
- the purposes for which the processing residues are used;
- the proportion of residues associated with the utilisation of wood products;
- the purpose for which the utilisation residues are used and
- the fate of redundant wood products.

When the proposed method is applied to Australia, and not including any potential storage in paper products, it is estimated that up to 70% of the C in commercial logs can be considered to remain in long-term storage, either in products in use, in landfills or through avoided fossil fuel use (Gardner *et al.* 2004).

Figure 1. Diagram of the main carbon flows in *TimberCAM*

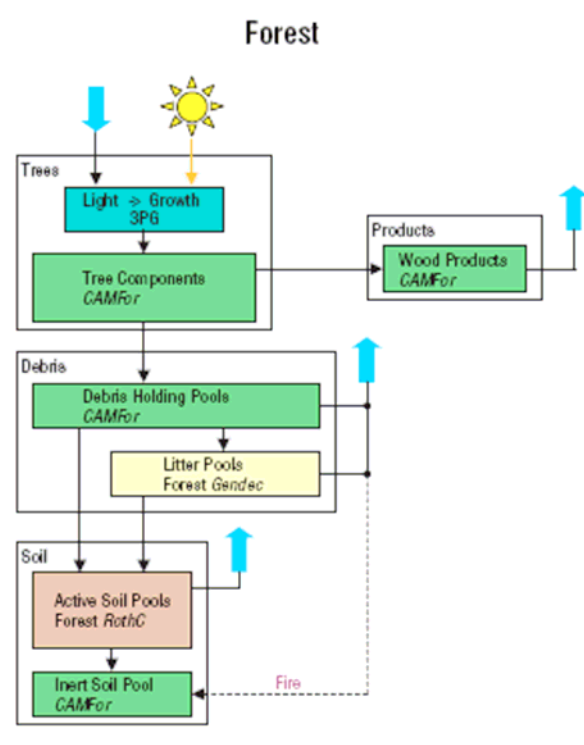


Australian Greenhouse Office (AGO)

The AGO commissioned Jaakko Pöyry (JP) to develop a model and methodology for C accounting in wood products for the AGO's NCAS (Figure 2). The reports (Jaakko Pöyry 1999 and 2000) are based on available information and consultation with the industry and provide an assessment of the size of the C pool in wood products in Australia. Wood products were allocated to five pools with assumed rates of decay:

- very short-term (decaying over 3 years) – paper products, softwood pallets and cases, plywood (formboard)
- short-term (decaying over 10 years) – Hardwood pallet and fencings and panel products (particleboard and MDF used for shopfitting and hardboard)
- medium-term (decaying over 30 years) – preservative-treated pine (decking and palings), panel products used in kitchen furniture, hardwood sleepers, plywood
- long term (decaying over 50 years) – preservative-treated pine (poles and roundwood), softwood furniture, hardwood poles, piles and girders
- very long-term (decaying over 90 years) – products used predominately in house construction

Figure 2. Diagram of the AGO's NCAS showing the main models used to estimate carbon stocks in trees, litter, soil and wood products



JP used housing starts figures as a base, then assumed an average wood content per house before converting the wood content to C. The JP model assumed a constant decay rate of the housing over 90 years, and it incorporates historical production data from ABARE's (Australian Bureau of Agricultural and Resource Economics) Forest Products Statistics series from 1944 to 1988. The report compares the use of three IPCC accounting approaches (see page 13) in the calculation of the total size of the C pool. The results are highly sensitive to changes in the assumption of housing decay over 90 years – the C in the “very-long term” pool, which is predominantly used in housing,

accounts for 75 to 80% of the total C pool. The model did not take into account any potential storage after disposal of wood products in landfills or any benefits of the displacement of fossil fuels due to use of bioenergy. The inclusion of storage in landfills would have greatly reduced the sensitivity of the results due to total stocks of C in housing and their assumed decay. Although the original JP modelling approach was more accurate than the IPCC default approach (see Introduction), it did not fully recognise the C storage potential of wood products.

More recently, MBAC Consulting updated and refined the original JP wood products C accounting model for the AGO's NCAS (Richards *et al.* in press). The updated model includes two new pools: a "landfill pool" for products disposed of in landfills, and a "bioenergy pool" for those redundant products and residues utilised to generate energy (Richards *et al.* in press). The main sources of information used in the model are the ABARE, CRCGA, state forest services, the FWPRDC, industry associations, CSIRO and forestry company databanks.

In the new AGO model, wood products are assigned to young, medium and old age pools, and materials leaving service may be used for bioenergy, placed in landfills, recycled or emitted to the atmosphere (Richards *et al.* in press). The inclusion of carbon in landfill makes an enormous difference to the estimate of total carbon storage in wood products: excluding wood products in landfill, the total C pool in 2003 was 85 and 95 Mt under two of the IPCC accounting approaches (Production and Stock-Change approaches, respectively). The inclusion of wood products in landfill increases those figures to 227 and 232 Mt, respectively (Richards *et al.* in press). Areas for further research identified by the AGO include refining the lifespan of wood products, researching the final disposal methods of wood products, with emphasis on further research on the rate and extent of decomposition of wood and paper in landfill, and refining the methodology for quantifying the C stock in housing.

PhD thesis (scheduled for completion in 2006) "Wood use and carbon sequestration in Australian housing" by Misheck Chomba Kapambwe, supervised by Professors Ian Ferguson, Peter Vinden and Snow Barlow. University of Melbourne

The main aim of this study was to estimate predictive relationships to determine carbon stocks in wood used in housing in Victoria. The main hypothesis of the thesis – that carbon stocks in houses in Victoria are substantial and increasing – was confirmed by the analysis. The research demonstrated that the volume of wood added to existing dwellings through addition projects in Victoria increased from 39,000 m³ in 1990 to 104,000 m³ in 2004. The estimates of actual timber usage in the dwellings were based on surveys of builders. The estimated wood wastage and losses (9%) matched those determined by the CRCGA work (8%, see page 3). The estimated life span (also used as half-life) of wood in dwellings determined also through surveys of builders (50 years) was also similar to that determined by the CRCGA based on surveys of home owners (44 years). It was then estimated that at least 25% of the carbon in the wood in the dwelling would be sequestered in use for at least 100 years. It is suggested that the methodology developed in this work could be applied to other states to provide a more-accurate national estimate of the use of wood in dwellings, and also to assist in carbon accounting for wood products. The author stated that "carbon in the Victorian housing sector should be included in the State and national carbon accounting system". However, the carbon from wood used in houses in Victoria is already included in the current NCAS, although the figures are not detailed on a state level. Further research

proposed by the author includes the testing of alternative models to predict number of dwellings built in the future and refinement of product half-lives.

Timber in building construction – ecological implications. Report prepared for the Timber Development Association of NSW and the FWPRDC by Dr William Lawson, School of Architecture, UNSW. 1996.

The bulk of this report deals with LCA and embodied energy concerning timber usage in buildings, with relevance for C storage in the built environment.

It is reported that timber can store up to 15 times the amount of C that is released during its manufacture. In a comparison between the embodied energy required to manufacture, assemble and maintain different wall materials, Lawson claims that, over a 40-year life, the embodied energy of a fully maintained timber-clad building will be lower than that of common alternatives such as double brick and steel frame.

The report briefly discusses possible scenarios following demolition, disassembly, disposal, re-use and recycling of building products. The various alternatives of use of wood products after demolition are discussed, although not from a C storage perspective. The very important issue of how to separate preservative-treated timber from untreated material following disposal is not discussed; eg it is difficult to separate CCA-treated wood from untreated wood on a visual basis. The contamination of the untreated wood with chemicals from preservative-treated wood is potentially the most important issue hindering the development of feasible options for re-use and recycling of timber.

The Environmental credentials of production, manufacture and re-use of wood fibre in Australia. Report prepared for AFFA by Peter Attiwill, Jacqueline England and Katherine Whittaker. September 2001.

This report is a literature review of the available data concerning the environmental properties of timber in Australia. It has useful diagrams showing the volumes of raw material used for the production of sawn timber and wood-based panels, with a breakdown of volumes of products manufactured and consumed by product type. However, most of the data is based on the generic figures published by ABARE coupled with the estimates given by Jaakko Pöyry on the recoveries of materials as products (Jaakko Pöyry 1999). Those recoveries, in turn, are based on best estimates in consultation with the industry, and not on actual mill studies. The report includes a discussion of the options for re-use and recycling of timber, MDF and particleboard, with some useful figures on generation of wood waste.

Other useful references for C accounting in wood products in Australia

Sawn Timber in Australia 2000-2015. Market opportunities, strategies and prospects for trade and investment. BIS Shrapnel Forestry Group.

This is a very comprehensive overview of the use of sawn timber in Australia, with emphasis on the residential building sector, which represents more than 70% of the total sawn timber used in Australia. Chapters 3, 4, 6, 7 and Appendices are of particular interest. This publication is an important addition to the generic ABARE statistics, as it

provides detailed estimates of the usage of sawn timber based on surveys of builders, manufacturers and other timber users.

The study provides detailed information about the usage of the main softwoods (including a breakdown for imported radiata pine) and imported and native hardwoods for a number of applications in residential buildings, including floor bearers, floor joists, floor boards; ceiling frames, wall frames, roof frames, window frames; architraves, skirtings, fascia boards; decks, pergolas, fencing, veranda posts, beams; internal linings, external cladding; external/internal doors and external/internal joinery. The report includes the percentage of treated timber used for each application in residential buildings, as well as information on the usage of furniture and pallets. More information on furniture usage is available in a separate publication by BIS-Shrapnel titled *The Wooden Furniture Industry in Australia: 2004-2008*.

The report is updated every 2 years, and a new report is due to be published early 2006.

ABARE (Australian Bureau of Agricultural and Resource Economics), *Australian Forest and Wood Products Statistics*, released quarterly

The ABARE publications are considered the most reliable information source on forest products statistics in Australia. The information for sawn wood and panel products is restricted to production and consumption volumes at a national level. However, it provides a good initial basis for the estimation of the size of the C pool.

International links

The bulk of the papers and reports written overseas concerning C storage in wood products are from groups in the USA, Europe (particularly Finland) and New Zealand.

USA

The National Council for Air and Stream Improvement (NCASI) has released a few reports of interest over the past few years (for more information please go to <http://www.ncasi.org/programs/areas/climate/sequestration.aspx>). The NCASI has also developed a tool that companies can use to estimate C storage in products in use for 100 years (NCASI 2004). The method applies half-lives to a number of product categories and assigns decay curves to each of them. The method does not take into account any C storage in landfills.

Miner (2003), from NCASI, provides a list of C storage factors for forest products in landfills. Landfill carbon storage factors are a measure of the proportion of the carbon in the wood product that is not degraded after disposal in landfills. On a C to C basis, Miner suggests the C storage factors for paper products range from 0.11 for office paper to 0.93 for newspapers. For wood and wood products, the figure quoted is 0.85, based on Miner's interpretation of the CRCGA landfill research results. Barlaz (2004), from North Carolina State University, provides a literature review on the decomposition of forest products in landfill, including a list of C storage factors of interest to the forest products industry. The quoted C storage figures for "wood and bark" and "wood waste" are 0.57 and 0.56. The problem with those figures is that they are based on Barlaz's laboratory experiments, in which tree branches are subjected to decomposition under optimal conditions (US EPA 2004). The results are then used by

the US Environmental Protection Agency (US EPA) as proxy for the decomposition of solid wood and panel products, which is clearly inappropriate.

Ken Skog, from the USDA Forest Service, is one of the lead authors of the Harvested Wood Products Chapter of the IPCC Guidelines for National Greenhouse Gas Inventories. Skog has co-authored several important papers in the area, including a study suggesting that decomposition of wood products in landfill is minimal (Micales and Skog 1997).

Europe

The main focus of the research groups working in the carbon in wood products area in Europe has been the development of modelling approaches. The most relevant models are *GORCAM* (Schlamadinger and Marland 1999), *CO2FIX* (Masera *et al.* 2003) and *EFISCEN* (Eggers 2002). The focus here will be on *GORCAM*, as its displacement modelling (bioenergy and wood products) is being incorporated into the AGO's *NCAS*.

GORCAM (Graz and Oak Ridge Carbon Accounting Model) is a spreadsheet model used to calculate C stocks in the forests and in wood products, with particular focus on bioenergy. It was developed by Bernhard Schlamadinger, from the Institute of Energy Research at Joanneum Research in Austria and Gregg Marland, from the Oak Ridge National Laboratory, in the USA. *GORCAM* accounts for the reduction of emissions due to displacement of fossil fuels by biofuels and it enables the user to account for any offset of fossil fuel carbon emissions through the substitution of wood products for other more energy-intensive materials. However, *GORCAM's* wood-product component is quite limited in its options: it does not include modelling options for any secondary processing after the sawn boards or panel products leave the processing plants, nor does it acknowledge any storage in landfills. Further details about *GORCAM* can be found at <http://www.joanneum.at/GORCAM.htm>.

CO2FIX and *EFISCEN* were developed primarily by G.J. Nabuurs from Wageningen University and Frits Mohren from Alterra, in the Netherlands. Details about *CO2FIX* and *EFISCEN* can be found at <http://www2.efi.fi/projects/casfor/> and <http://www.efi.fi/projects/forsce/> respectively.

Kim Pingoud, from the Finnish Forest Research Institute, is one of the lead authors of the Harvested Wood Products Chapter of the IPCC *Guidelines for National Greenhouse Gas Inventories*. He has published a number of papers, and the Joanneum Research Institute website lists many of his abstracts (<http://www.joanneum.ac.at/iea-bioenergy-task38/>). This web link also lists abstracts for a number of papers published by Bernhard Schlamadinger.

The COST 21 Program (European Cooperation in the Field of Scientific and Technical Research) focused on the quantification of carbon storage in forest ecosystems, although some of the work also involved wood products. A series of workshops was held over the period of the project and presentations are available at <http://www.efi.fi/coste21/info/action/index.html>. Arno Frühwald, a Professor of Wood Physics and Wood Technology from the University of Hamburg, in Germany, was involved in the COST 21 Program. As part of his work, he compared the environmental and energy balances of wood products and major substitutes and conducted a study into the role of wood products as carbon sink in Germany (Frühwald 2001).

New Zealand

Andrew Buchanan (University of Canterbury) analysed the impact of wood as a building material by considering both emissions and C stored in the wood. However, he did not acknowledge long-term storage in landfills and uses a very low default average life of 40 years for solid wood products (Buchanan and Levine 1999). Therefore, his results potentially significantly underestimate the storage potential in wood products. Justin Ford-Robertson (Ford-Robertson Initiatives) is a contributing author to the Harvested Wood Products Chapter of the IPCC *Guidelines for National Greenhouse Gas Inventories*. Ford-Robertson is also a contributor to the Forestry Chapter of the latest IPCC *Assessment Report (AR4)*, and he is working to have carbon storage in wood products acknowledged in the Report. Ford-Robertson proposed one of the accounting approaches (simple decay approach) outlined in the next section.

Intergovernmental Panel on Climate Change (IPCC) and United Nations Framework Convention on Climate Change (UNFCCC) documents

The UNFCCC was the first international agreement under which countries agreed to take action on climate change in 1992. The IPCC was established in 1988 and it works closely with the UNFCCC producing *Guidelines for National Greenhouse Gas Inventories*, assessment reports and technical papers. Links to documents relevant to wood products are included in the references. As accounting of emissions and sinks in the wood products pool is excluded from the first period of the *Kyoto Protocol (KP)*, discussions are being held to decide on approaches and methods to account for them.

Accounting approaches

There are five approaches proposed by the IPCC that can be used to estimate C stock changes in wood products in National Inventories. The “Instant Oxidation” default approach (discussed in the “Introduction”), is the most conservative approach. The alternatives vary in their treatment of traded wood products, that is, whether it is the exporter or the importer that reports the emissions/removals. Under the “Stock Change Approach”, a country would report change in stock of the total wood products pool within its national borders, for products produced domestically and imported. Under the “Production Approach”, a country would report stock changes in all wood products that have originated from that country, whether domestically consumed or exported. A third approach reports the atmospheric flux of C rather than the stock change (the “Atmospheric Flow Approach”); removals of C dioxide from the atmosphere due to forest growth are accounted for in the producing country, whereas emissions of C from decay or burning of wood products are accounted for in the consuming country (UNFCCC 2003). Under the “Atmospheric Flow Approach”, exports and imports of wood products must be reported (Cowie 2005). More recently, a “Simple-Decay” approach has been proposed (Ford-Robertson 2003), where the atmospheric flux of C from wood products produced in the country is reported. This approach has the same boundary as the “Production Approach”, but reports fluxes of gases rather than C stock changes. The proposed approaches are described in detail in a technical paper released by the UNFCCC (UNFCCC 2003).

The choice of accounting approach will impact the market for wood products for countries signatories to the KP (UNFCCC 2003). Adoption of the IPCC “Instant

Oxidation” default approach is likely to lead to increases in the prices of harvested wood and a reduction in harvested volumes, since the cost of reducing emissions is added to the production costs. Neither the “Production” nor the “Stock-Change” approaches penalise forest harvesting. The “Stock-Change Approach” penalises exports of wood products as they are considered an immediate emission, but an increase in domestic and imported wood products may offset the export penalties, depending on the types of products manufactured and the methodology used to account for C. The “Production Approach” does not penalise exports of wood but emissions from the decay of wood products have to be compensated by the producing country. The market price of wood products is also expected to increase under both the “Production” and “Stock-Change” approaches. However, under the “Atmospheric-Flow Approach”, the market price for wood products is expected to increase only slightly, as it would result in only a slight increase in production costs, since only emissions from harvesting slash would be reported (UNFCCC 2003). The impact of the different approaches, however, cannot be quantified in isolation as there are many other factors that would impact on prices and quantities of wood products.

Methods

Under the IPCC Guidelines, country-specific methods may be used to estimate changes in inventories of wood products; for example the changes in housing stocks may be estimated by multiplying the average wood product content per square meter of floor space by the total floor space. The C held in wood products in landfill may be reported both in the Waste and Harvested Wood Products Chapters of National Greenhouse Gas Inventories. The proposed methods outlined in the Waste Chapter use current and historical waste disposal at landfills, and countries may choose between using default decay parameters based on waste composition or average parameters for disposal of bulk waste. The use of decay parameters based on waste composition is preferred by the IPCC for estimating the C in wood products stored in landfills.

Relevant UNFCCC and IPCC Literature

UNFCCC documents on land use, land use change, and forestry
http://unfccc.int/methods_and_science/lulucf/items/1084.php

Harvested wood products guidance from IPCC 2003 *Good Practice Guidance for Land Use, Land Use Change and Forestry*
http://www.ipcc-nggip.iges.or.jp/public/gpplulucf/gpplulucf_files/Chp3/App_3a1_HWP.pdf

IPCC 2003 Harvested Wood Products Expert’s Workshop
<http://unfccc.int/resource/docs/tp/tp0307.pdf> and
<http://unfccc.int/resource/docs/tp/tp0307c01.pdf>

IPCC 2000 *Special Report on Land Use, Land-Use Change and Forestry*
http://www.grida.no/climate/ipcc/land_use/index.htm

Key Interested Parties

The number of parties interested in the developments in the carbon storage in wood products in Australia has grown over recent years.

- **CRCGA, Commonwealth and State Agencies**

The CRCGA and the AGO are the two main organisations actively commissioning and carrying out research in the area. However, the CRCGA will be finalising its activities by July 2006. The CRCGA research filled some of the knowledge gaps identified in the Jaakko Pöyry reports commissioned by the AGO.

Forests NSW is the main state agency with interest in this area, and has supported this line of work through its commitment to the CRCGA as a research partner, contributing both cash and in-kind resources. Forests NSW has a carbon accounting system in place that is accredited under the NSW Greenhouse Gas Abatement Scheme (NSWGGAS) to provide carbon credits.

- **Industry associations**

Both A3P and NAFI are aware of the CRCGA research (through presentations given) and of international developments in the area. A3P sent a representative to a workshop co-organised by CRCGA researchers in May 2005 in North Carolina to discuss the decomposition of forest products in landfills (Ximenes *et al.* 2005).

- **Private companies**

Carter Holt Harvey (CHH) has expressed interest in the potential for wood products to be included in the NSWGGAS. Discussions have been held between CHH and Forests NSW to develop a joint proposal for consideration by IPART (Independent Pricing and Regulatory Tribunal), which regulates the rules for greenhouse gas abatement in NSW. The proposal will be largely based on actual production data and results of the CRCGA *Carbon in Wood Products* project.

Tony Richardson, a director of a company called Green and Gold Tree Farms, presented a paper at the *Greenhouse 2005* conference in November 2005, in which he examined the cost-effectiveness of C sequestration in harvested eucalypt plantations using assumptions of the fate of C in wood products (Richardson 2005). He came to the conclusion that, under the assumptions used, harvested plantations were much more cost-effective in sequestering C in the long term than unharvested plantations. In his proposed C sequestration program ("TreeSmart"), Richardson accounts for the C retained in wood products using a modelling approach very similar to that used in *TimberCAM*.

Key Policy issues

The work carried out in the carbon storage in wood products has highlighted some important policy issues for consideration.

Carbon trading

The *Kyoto Protocol* (KP) allows international carbon trading between signatories to meet their greenhouse gas emission targets, relating to emissions and removals of carbon for the first commitment period (2008-2012). Under the KP, eligible forestry projects must have been established on cleared land since 1990. Australia cannot take part in international trading under the KP since it has not ratified it. However, the interest in trading within and between States is rapidly growing. New South Wales has its own emission trading scheme – the NSWGGAS, which is aimed at reducing per capita emissions from electricity generation. Under the current rules of the Scheme, based on the KP rules, forestry offsets are allowed but continuing carbon storage in wood products is not recognised. In addition, they are required to store the quantity of carbon sequestered by the trees for 100 years. All States and Territories are now considering a national emissions trading scheme (www.cabinet.nsw.gov.au/greenhouse/emissionstrading) via the National Emissions Trading Taskforce.

This review has shown there is overwhelming evidence that a significant proportion of C sequestered in trees is retained in long-term storage in wood products, even after disposal in landfills. The implications of including wood products in emission trading schemes would be significant and of a very beneficial nature to the wood products industry as a whole. Under the NSWGGAS, the particleboard and MDF manufacturers could be the main beneficiaries initially, as a proportion of the feedstock used for the manufacture of those products is already sourced from potentially eligible thinning material. For sawn timber, eligible softwood plantations are likely to benefit sooner as second thinnings are carried out and sawlogs are obtained. A study by the CRCGA revealed that at a second thinning of radiata pine, sawlogs comprised nearly 90% of the commercial log biomass.

The main barrier for the immediate inclusion of all types of wood products in the trading schemes is the current requirement for plantations to be established post 1990. However, the fact that a significant proportion of the carbon in wood products is stored for many decades – and not emitted in the year of harvest - provides a strong argument for this requirement to be removed, as the storage in the products is incremental with each harvest, independently of the origin of the logs. There would also be a strong argument to remove the “100-year” permanency rule, as in fact a frequent harvest regime within that period of time would maximise the carbon sequestration benefits. This would create further incentive for the establishment of carbon sequestration projects.

The following key benefits of the uptake of wood products in C trading are envisaged:

- Inclusion of wood products in C credit schemes would immediately increase the value of C, as the penalty currently paid at the time of harvest would be greatly reduced;
- An increased return from C trading would extend interest in the establishment of more plantations for C sequestration;

- The increased revenue for the forest growers would flow on to the wood products manufacturers, probably either in the form of C credits or reduced costs in purchasing logs – depending on who owns the credits;
- Reduced processing costs would result in cheaper wood products, making them more competitive against alternative building materials.

A decision would still need to be made regarding ownership of the credits – i.e. whether the forest grower or the wood product manufacturer will own the credits.

To have wood products included in C trading schemes would require a concerted effort from industry (from forest growers to large wood product manufacturers) to lobby greenhouse gas regulators, such as IPART in NSW. This effort should be underpinned by solid science and should be helped by the fact that, as mentioned previously, the AGO's proposed modelling for wood products in the NCAS already acknowledges long-term C storage in wood products.

Energy rating schemes

States are increasingly relying on energy rating schemes to guide the choice of construction materials in the residential building sector. Current energy rating schemes are based on the operational energy associated with different materials. This may seriously disadvantage wood products, as none of the greenhouse benefits associated with the manufacture of timber are taken into account. It is important for the greenhouse impacts associated with the whole life cycle of building products to be considered, including the greenhouse impacts of disposing of building products. The recent finding that wood products do not degrade significantly in landfills will improve the greenhouse performance of timber against alternative materials, as much less methane will be assumed to be generated by wood products in landfills.

Disposal of wood products

In the waste area, the recent push by government agencies to promote the “Extended Producer Responsibility” concept to reduce waste and its impact on the environment may impact the wood products industry in the near future. The issue is particularly relevant for treated timber, which has been identified by the NSW EPA as a “waste of concern”. Companies producing these wastes will be required to take early action to reduce the volume and environmental impact of these materials in the waste stream. The *Wood in Landfill* project carried out by the CRCGA has demonstrated that from a carbon storage perspective, landfills are effective in preserving wood products, preventing the return of C to the atmosphere. Given the growing concern about climate change due to high levels of greenhouse gas emissions, this important finding should also be taken into consideration by environmental agencies in the development of policies to deal with waste. However, one of the main problems in the disposal of wood waste is the lack of effective techniques for screening redundant preservative-treated wood at the disposal end. This may result in the whole of the wood waste stream being declared contaminated and having to be disposed of at high costs in specialised landfills. It is important for the industry to look carefully into the various disposal options available for redundant wood and residues, with particular consideration to economic and environmental implications. Utilisation of redundant products for

bioenergy, displacing fossil fuel use, may give the greatest greenhouse benefits. There may be bioenergy technologies such as pyrolysis that can also utilise treated wood.

Carbon sequestration in LCA

Finally, it is important to work with LCA practitioners to have the C storage in forests and in wood products properly acknowledged in LCAs as a benefit gained due to forestry activities. The main issue here is that LCAs are normally conducted without any recognition of carbon storage in the wood. It does not seem fair that carbon dioxide emissions are treated as a burden in LCAs, but the fixing of the C in trees and its retention in wood products are not recognised. This lack of recognition is detrimental to the overall outcomes for wood products in LCAs when compared to alternative materials. In a review for NCASI, Franklin Associates (Franklin Associates 2004) reports that “there is no uniform peer-reviewed methodology for characterising sequestration in the ISO standards, nor has one been adopted by LCA practitioners”.

Key R&D Priorities

The key R&D priorities identified here are those that are most likely to impact the sectors of the forest products industry represented by the FWPRDC.

- **Development of specific C storage factors for a range of important types of wood products**

The life cycle of different types of wood products may differ considerably, depending primarily on recoveries during manufacture, service life and end-of-life disposal options. The development of carbon storage factors is essential to underpin long-term carbon storage claims should wood products be included in carbon trading schemes. It is particularly relevant for wood products used in the building industry, as it would provide further concrete evidence of the environmental friendliness of wood products. The data required would also be valuable in the development of LCAs for wood products. The AGO has specifically identified refining the assumed service life of wood products and the methodology used to determine the carbon sequestered in housing as priority areas for further research and development that is relevant to the NCAS.

- **Development of an energy budget for wood products**

The development of an energy budget for wood products involves determining the energy usage associated with the main stages in the life cycle of wood products: extraction, transport, processing and installation. Wood products already have a significant advantage over competing products since a large proportion of the production energy required is from a renewable source (residues). An energy budget that accounts for both renewable and non-renewable energy sources is critical for use in LCAs. Given the increased emphasis on energy rating systems for residential developments, the development of energy budgets is particularly urgent for wood products used in the building industry.

- **Decomposition of wood products in landfills**

Given the continuing reliance on landfills as the main disposal option for wood products in Australia, more excavations are required to confirm preliminary findings of minimal decomposition of wood products in landfills. The data developed here would be critical for the determination of the carbon storage factors suggested in point “1”, and also as part of LCAs that include product disposal in their boundaries. The AGO has specifically identified research into final disposal methods of wood products and further research on the rate and extent of decomposition of wood products in landfills as priority areas for further research and development that is relevant to the NCAS.

- **Disposal options for wood products**

The fate of wood products at the end of their service life is of direct relevance to the carbon storage potential of wood products. Depending on the options available (eg whether the product is burnt to waste, recycled, put in landfills or used for energy generation), the carbon storage outcomes will be very different. In order to achieve the best outcome for the wood products industry and for the environment, a LCA of the alternative disposal options for wood products would need to be conducted. The study should also include an economic analysis of alternative options for disposal of wood products, particularly urban wood waste.

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Glossary

ABARE	Australian Bureau of Agricultural and Resource Economics
AGO	Australian Greenhouse Office
A3P	Australian Plantation Products and Paper Industry Council
C	Carbon
Carbon storage factor	Proportion of the carbon in the wood product that is not emitted into the atmosphere
CHH	Carter-Holt Harvey
CRCGA	Cooperative Research Centre for Greenhouse Accounting
CO₂-equivalents	Carbon dioxide equivalents
CO₂FIX	Carbon accounting model
COST 21	European Cooperation in the Field of Scientific and Technical Research – Contribution of Forests and Forestry to Mitigate the Greenhouse Effect
EFISCEN	European Forest Information Scenario Model
Ensis	The joint venture of CSIRO and Scion
EPA	Environmental Protection Agency
GORCAM	Graz and Oak Ridge Carbon Accounting Model
IPART	Independent Pricing and Regulatory Tribunal
IPCC	Intergovernmental Panel on Climate Change
JP	Jaakko Pöyry
KP	Kyoto Protocol
LCA	Life Cycle Assessment
Mt	Million tonnes
NAFI	National Association of Forest Industries
NCAS	National Carbon Accounting System
NCASI	National Council for Air and Stream Improvement
NGGI	National Greenhouse Gas Inventory
NSWGGAS	New South Wales Greenhouse Gas Abatement Scheme
TimberCAM	Timber Carbon Accounting Model
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture

This publication has been prepared for the Forest and Wood Products Research and Development Corporation by the Cooperative Research Centre for Greenhouse Accounting. The publication was prepared for the purposes of outlining the current state of knowledge and information relating to C storage in wood products in Australia, with emphasis on the built environment and waste disposal.

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