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Allocation of New Zealand's Harvest to Domestic and Export Products

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Objective

The objective of this report is to provide information that will allow New Zealand to meet the new requirements for Kyoto Protocol (KP) accounting and reporting relating to harvested wood products (HWPs). This requires the ability to allocate the carbon in New Zealand's annual harvest to the three recognised product types: sawn wood, panels and paper.

Key Results

Data on the production, export and import of HWPs was obtained from FAO and a spreadsheet model developed to reflect the accounting rules and IPCC guidance. The FAO data and default IPCC half-lives are by definition sufficient to meet KP reporting standards, but do not cover HWPs produced from exported raw materials. Conversion of exported raw materials to HWPs was estimated, but without verifiable data the estimates do not meet good practice standards so would instead be treated as an instantaneous emission. This is not an issue for UNFCCC reporting, because in that case the approved methodology assumes that the domestic conversion proportions apply to exported logs.

Model results indicate that a relatively small proportion (30%) of the carbon harvested in roundwood is captured in HWPs manufactured in New Zealand and that this proportion will decline unless the expected increase in harvest is matched by an increase in domestic processing. The default IPCC half-lives appear to be suitable for HWPs used in New Zealand, but are likely to over-estimate life spans in the main export markets. However data on the allocation of New Zealand-grown HWPs to sub-markets is scarce.

Implications of Results

Roundwood removals during the second commitment period are expected to be mainly from pre-1990 forests. Accounting for these forests is against a reference level so the exclusion of exported raw materials from accounting will have a neutral effect since the same assumption is made in reporting as in the reference level. The issue is of greater importance for post-1989 forest harvesting, which will be more significant after CP3. Other accounting exclusions remove HWPs originating from imports, deforestation and non-forest land uses, but the amounts involved are relatively small. The use of half lives specific to New Zealand-grown HWPs in export markets may also have a negative impact as radiata pine tends to be used in market segments with short life spans.

Further Work

- Estimate the HWP variables required for UNFCCC reporting using the data compiled.
- Initiate research into appropriate half-lives for HWPs in New Zealand.
- Overcome the exclusion of exported raw materials from accounting by either negotiating broader rules and/or guidance that allows conversion assumptions to be applied to raw material exports, or collecting appropriate data in major export markets. Alternatively the issue can be minimised by increasing the proportion of domestic processing.
- Improve estimates of the allocation of exported HWPs to sub-markets and their corresponding half lives.
- Develop an inventory approach to verify HWP pool stocks and stock changes.
- Develop or adapt a Tier 3 'stump-to-atmosphere' HWP material balance model.

Glossary

Article 3.3	Kyoto Protocol article defining activities for which accounting is mandatory in the 1st and 2nd commitment period. Covers afforestation, reforestation and deforestation since 31 December 1989.
Article 3.4	Kyoto Protocol article defining activities for which accounting was optional in the 1st commitment period. Includes forest management (emissions and removals in forests established before 1 January 1990), for which accounting is now mandatory in the 2nd commitment period.
AR, ARD	Afforestation, Reforestation and Deforestation – Kyoto Protocol Article 3.3 activities.
CMP	Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol (CMP). All States that are Parties to the Kyoto Protocol are represented at the CMP, while States that are not Parties participate as observers. The CMP reviews the implementation of the Kyoto Protocol and takes decisions to promote its effective implementation.
CP1, CP2	First (2008-2012) and Second (2013-2020 Commitment Periods of the Kyoto Protocol
Durban	Venue for the 7th CMP, where agreement was reached on Kyoto Protocol second commitment period accounting rules (Decision 2/CMP.7).
FAO	Food and Agriculture Organisation (of the United Nations)
FM	Forest Management – a Kyoto Protocol Article 3.4 activity.
FMRL	Forest Management Reference Level – projected net emissions during the second commitment period to be used as the baseline for determining accounting credits and debits under the Kyoto Protocol.
HWP	Harvested wood products, defined as sawn wood, panels, and paper and paperboard according to FAO definitions.
IPCC	Intergovernmental Panel on Climate Change - scientific body that reviews and assesses the most recent scientific, technical and socioeconomic information produced worldwide, relevant to the understanding of climate change.
KP	Kyoto Protocol - international agreement linked to the United Nations Framework Convention on Climate Change, which commits its Parties by setting internationally binding emission reduction targets.
LULUCF	Land Use, Land Use Change and Forestry – a sector used for national greenhouse gas inventory reporting under the UNFCCC.
MDF	Medium density fibreboard, a panel product.
UNFCCC	United Nations Framework Convention on Climate Change (“the Convention”), aimed at stabilising greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with the climate system.

Introduction

OBJECTIVE

National statistics on HWP production and trade are used for two different purposes related to climate change mitigation: greenhouse gas inventory reporting and Kyoto Protocol accounting. The objective of this report is to provide information that will allow New Zealand to meet the new requirements for Kyoto Protocol accounting and reporting relating to harvested wood products (HWPs). This requires the ability to allocate the carbon in New Zealand's annual harvest to the three recognised product types: sawn wood, panels and paper.

The key research questions to address are:

1. For Kyoto Protocol second commitment period accounting:
   What proportion of the annual harvest from (a) Pre-1990 forests (Article 3.4 Forest Management), and (b) Post-1989 forests (Article 3.3 Afforestation/Reforestation) is expected to be converted into each semi-finished product category (sawn wood, panels and paper) annually from 2013-2020?

2. For UNFCCC national greenhouse gas inventory reporting:
   What was the annual Production, Imports and Exports of solid wood and paper from 1900-2011, and therefore what was the annual change in the HWP in service pool from 1990?

There has been intensive debate internationally on the merits of the inclusion of HWPs in carbon accounting and on the most appropriate approach to apply. Commentary on that debate is beyond the scope of this report.

BACKGROUND[1]

UNFCCC Reporting

Under the United Nations Framework Convention on Climate Change (UNFCCC), Parties have a commitment to calculate and report on their national carbon budget, as part of their national greenhouse gas inventory. This includes estimating carbon stock changes within the landuse, land use change and forestry (LULUCF) sector. For reporting under the UNFCCC, carbon stocks within forests do not include carbon within harvested wood. No agreement could be reached on the appropriate way to account for carbon in HWPs, with disagreement centring on whether parties should report the carbon in products they produce regardless of where they are consumed, or report the carbon in products consumed within their country regardless of where they were produced.

Currently reporting of the carbon stock in harvested wood products is optional and is presented in national greenhouse gas inventories as an information item. Guidance on HWP reporting was published in the "2006 IPCC Guidelines for National Greenhouse Gas Inventories" (2006-Guidelines; IPCC, 2006). This guidance allows Parties to choose between three Tiers of methodologies for estimating the contribution from HWPs, in addition to the option to assume that carbon in stems removed from the forest is released to

[1] More detailed information on UNFCCC and Kyoto Protocol reporting requirements can be found in Appendix I.

the atmosphere at the time of harvest. Tier 1 provides a default methodology for the calculation of a range of variables that can be used to estimate changes in the stocks of solid wood and paper under the four competing accounting approaches recognised. This default methodology is based on the use of FAO production, export and import data. The "in service" life span of HWPs is modelled using half-lives.

When the default Tier 1 methodology is applied, the carbon within wood products is captured by three separate and unconnected models (Figure 1). Carbon sequestered in growing trees through photosynthesis is captured within the above-ground biomass pool of the forest model. This may involve field inventory, remote sensing or growth simulation models. At the time of harvest it is modelled as an instantaneous emission from the forest pools. The Tier 1 HWP model then captures the carbon in solid wood and paper produced that year based on FAO product quantity data converted to carbon, with no reference to the above-ground biomass loss in the forest model. The carbon then leaves the HWP pool at the end of its service life, as determined by half lives. This instantaneous emission is balanced to some extent by the inclusion of HWPs as a waste stream input into the Waste sector landfill model. However, all CO_2 released from HWP is included in the LULUCF Sector – CO_2 released from wood burnt for energy is not included in the Energy Sector totals and CO_2 released from HWP in SWDs is not included in the Waste sector total emissions, although methane emissions are included.

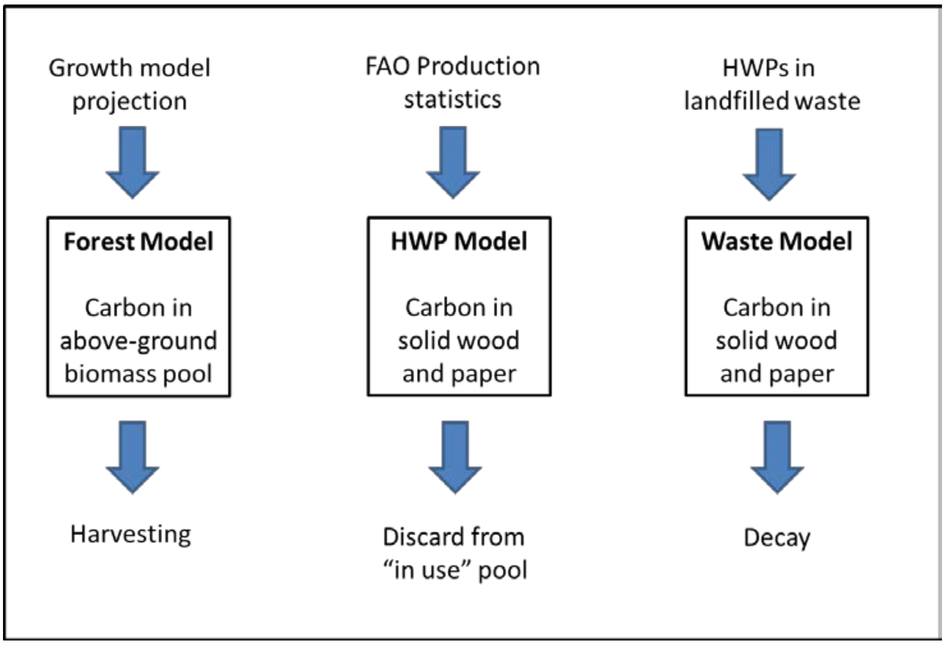

Figure 1. Default UNFCCC models for tracking the carbon in HWPs

In order to capture changes in the HWP pool from 1990, a default procedure is available to initialise the pool using estimates and data on production, exports and imports from 1900. Tier 2 uses the same methodology but with country-specific parameters while under Tier 3 Parties can develop their own methodology based on models, product inventories or a combination of both. Two or more of the models in Figure 1 may then be directly linked.

Kyoto Protocol Reporting

The Kyoto Protocol set up binding commitments to limit net emissions of greenhouse gases. Under the first commitment period of the Kyoto Protocol (2008 to 2012), atmospheric greenhouse gas removals from post-1990 afforestation and reforestation, and emissions due to deforestation counted towards the target. Carbon in HWPs was assumed to be emitted at the time of harvest (Table 1).

For the second commitment period (2013 to 2020), mandatory accounting has been extended to include forest management (i.e. emissions and removals on lands that were forested before 1 January 1990). However, accounting for these emissions and removals is to be relative to a business-as-usual Forest Management Reference Level (FMRL). Only net emissions that are above the reference level will generate a debit. In addition, the new rules allow for HWPs to be included in accounting, which has the effect of delaying the return of carbon to the atmosphere to reflect the life span in-use of products. Some additional limitations have been imposed, as discussed later.

Once again three Tiers are available for KP reporting (Table 1). Tier 1 assumes instantaneous emission of carbon in harvested logs at the time of harvest. This assumption of instantaneous emissions is mandatory under all Tiers for harvested wood products arising from deforestation or non-forest land uses (e.g. shelterbelts), and must also be used for wood not allocated to one of three broad product categories (sawn wood, panels and paper). In New Zealand's case, a Tier 1 approach is not allowed for the remaining HWPs that arise from forest harvesting activity, because at least some default data of an acceptable standard is considered to exist[2].

Table 1. Methodology Tier Summary for Reporting HWPs

	UNFCCC inventory	Kyoto Protocol CP1	Kyoto Protocol CP2
Tier 1	All HWPs from all activities: FOD for two product classes since 1900; IPCC default parameters	All HWPs: instantaneous emission	All HWPs: instantaneous emission
Tier 2	As Tier 1 but country-specific parameters	All HWPs: instantaneous emission	Depends on Activity: Instantaneous emission if origin is deforestation or non-forest; if harvesting use FOD for three product classes; HWP pool change from 1990 for *post-1989 AR harvest*; HWP pool change from 2013 for *pre-1990 FM harvest* (accounting against FMRL); imports excluded.
Tier 3	As Tier 1 but country-specific methods and parameters	All HWPs: instantaneous emission	As Tier 2 but country-specific methods and/or parameters

FOD = First Order Decay
Post-1989 AR harvest refers to harvesting of forests planted after 31 Dec 1989 (KP Afforestation/Reforestation)
Pre-1990 FM harvest refers to harvest of forests planted before 1 Jan 1990 (KP Forest Management)

Tier 2 is based on first order decay of carbon allocated to the three semi-finished product categories, with the following half-lives: sawn wood 35 years; panels 24 years; and paper 2 years. HWPs derived from post-1989 forests are accounted for using activity data starting from 1990. Pre-1990 forests are accounted for against the FMRL which in New Zealand's case is based on a projection – this means the pool is initialised in 2013 and no inherited emissions are accounted for.

[2] Decision 2/CMP.7 Paragraph 29. Default data from FAO covers domestically-produced HWPs.

Tier 3 allows the use of country-specific methods "provided that verifiable and transparent activity data are available and that the methodologies used are at least as detailed or accurate"[3]. Tier 3 may simply be the Tier 2 methodology with different variables (country-specific half-lives, emission factors, product classes) or could involve different approaches including product inventory methods.

Kyoto Protocol accounting for HWPs is much more complex that reporting under the UNFCCC although under Tier 2 the same FAO data can be used (Table 1). Complexity arises because of the need to distinguish:

- HWPs from each forest sub-category (pre-1990 natural forest, pre-1990 planted forest, post-1989 forest) and from non-forest land uses (e.g. shelterbelts);
- HWPs from harvest and from deforestation;
- HWPs by importing country (recommended though not mandatory).

Kyoto Protocol accounting also uses three pools rather than just two. Some complexity is reduced because there is no need to estimate inherited emissions from HWPs produced annually since 1900, although this is still required for UNFCCC greenhouse gas inventory reporting.

Text from the Durban Decision 2/CMP.7 relating to HWPs is included in Appendix I. Guidance to be provided by the *2013 Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol* (2013SG-KP) will assist Parties in interpretation. This report is based on information provided in the early stages of the development of this guidance. It must be recognised that this guidance has been neither finalised nor adopted for use in Kyoto Protocol reporting.

[3] Decision 2/CMP.7: Paragraph 30

Method

GENERAL APPROACH

This report compiles the data necessary to apply the Tier 1 approach for UNFCCC inventory (Convention reporting). This then forms the basis for allocating New Zealand's annual harvest to the three IPCC product categories required for Tier 2 reporting for the second commitment period of the Kyoto Protocol.

This approach is based on the use of data managed by the Food and Agriculture Organisation of the United Nations (FAO), which in New Zealand's case is supplied to FAO by MPI and Statistics New Zealand. Data is available in the online FAOSTAT database for the years from 1961 to 2011, and a default IPCC approach is available to back-fill the time series to 1900. This ensures that inherited emissions are available for Convention reporting from 1990. HWPs originating from harvesting before 1 January 2013 can be ignored for Kyoto CP2 accounting and reporting under the FMRL (pre-1990 forests). Harvesting of post-1989 forests begins in a very small scale in 2005.

Actual reporting of commitment period emissions and removals will be based on data captured by the Land Use and Carbon Analysis System (LUCAS).The proportional allocation of carbon to each product type is calculated using the FAO data so that these proportions can be applied to harvest and deforestation emissions estimates produced by LUCAS.

In addition to the default data and parameters suitable for Tier 1 UNFCCC inventory reporting and Tier 2 Kyoto Protocol reporting, country-specific parameters were obtained. The approach then qualifies as a higher Tier – Kyoto Protocol reporting using country-specific parameters (eg. half-lives) is automatically Tier 3. In contrast, Tier 3 reporting under the UNFCCC requires both country-specific parameters and methods (Table 1). This report does not attempt to create a Tier 3 HWP model for New Zealand's UNFCCC reporting or to model the full material balance of all fibre flows.

STEPS FOR KYOTO PROTOCOL REPORTING

The following steps are based on the draft guidance for reporting under the Kyoto Protocol.

1. **FAO production, import and export data.** Obtain transparent and verifiable data that represents information on the material use of wood (products in service). For UNFCCC reporting, FAO data since 1961 (default) or 1900 (if available) is required. Kyoto reporting requires a subset of this: FAO data since 1990 is required for harvesting of post-1989 forest, and since 2012 for harvesting of pre-1990 forest.

2. **Conversion to carbon.** Convert HWP product data to carbon using default or country specific factors.

3. **Domestic origin proportion.** Estimate the share of HWP originating from forests within the country using the domestic share default calculation or an alternative based on country-specific information.

4. **Allocation to activities.** Estimate the share of HWP originating from Afforestation, Reforestation and Deforestation (ARD) lands under Article 3 paragraph 3 and Forest Management (FM) lands under Article 3 paragraph 4, as the methods for estimating the HWP contribution differ. Include also the share derived from non-forest sources that are accounted for on the basis of instantaneous emissions.

5. **Obtain country-specific half-lives if available.** Parties are encouraged to use separate country-specific half-lives (a) for domestic use and (b) as applied by the importing country for the exported HWP categories.

6. **Estimate carbon stock and annual change.** Estimate the annual stock change by product pool and activity based on instantaneous emissions for deforestation and non-forest sources, and first order decay for harvesting.

The results section discusses data, assumptions and calculations made to carry out these steps:

- HWP definitions
- FAOSTAT Production, Import and Export data
- Backfilling data to 1900
- Projecting data to 2020
- Product to carbon conversion
- Domestic origin proportion
- Allocation to activities
- HWP half-lives
- Estimation of carbon stock changes

Results

HWP DEFINITIONS

Accounting for HWPs under Kyoto is limited to the pool of harvested wood products in-use, with first order decay used to describe emissions from that pool. Under the default approach described in the draft guidance it is good practice to assume that the three HWP categories named in Decision 2/CMP.7 match the definitions of semi-finished wood products of the international classification system of forest products used by FAO. Paragraph 30 of the Decision allows for a Tier 3 approach, stating that a country may "account for…[*sawn wood, panels and paper*]… in accordance with the definitions and estimation methodologies in the most recently adopted IPCC guidelines and any subsequent clarifications agreed by the Conference of the Parties". The draft guidance currently limits products in a Tier 3 approach to either disaggregations of the three Tier 2 product classes, or finished products made from one or more of those products.

FAOStat[4] contains both production and trade data. Traded products are classified using the Harmonised Commodity Description and Coding System (HS) of tariff nomenclature provided by the World Customs Organization (WCO). This system came into force in 1988.

The forestry domain of FAOStat comprises:

- ForeStat – production, import and export statistics from 1961 onwards, covering industrial roundwood, wood fuel, sawn wood, wood-based panels, wood pulp, paper and paperboard and recovered paper.
- Forestry trade flows – forest products bilateral statistics from 1997 onwards.

Earlier FAO data is available in published year books online from 1947[5].

The FAO data (and the IPCC methodology) does not include trade in finished products such as prefabricated houses, furniture, or books. Product categories vary slightly for production and trade and different aggregations are used over the time series. In most cases products are coded as either Coniferous (C) or non-coniferous (NC). Tropical timber is separately coded as "NC.T".

Figure 1 shows the classification scheme for Roundwood, the broadest category of production. Roundwood consists of industrial roundwood plus charcoal/fuel wood. Only industrial roundwood is of interest for HWP accounting because carbon in wood used for energy is assumed to be instantly emitted at the time of harvest. Industrial roundwood is the raw material used to produce the three semi-finished product classes that are captured within the HWP pool for carbon accounting purposes; sawn wood, panels and paper and paperboard.

Full FAO product definitions are given in Appendix II. From 1990, trade statistics for roundwood have aggregated sawlog and veneer logs, pulpwood and other industrial roundwood into a single product: "Industrial Roundwood, wood-in-rough (Ind Rwd wir)". Summary definitions provided by FAO are:

[4] *http://faostat.fao.org*
[5] http://www.fao.org/forestry/statistics/80570/en/

Industrial roundwood – includes sawlogs or veneer logs, pulpwood, and other industrial roundwood. In the case of trade, chips and particles and wood residues are also included.

> ***Pulpwood and particles*** - Includes pulpwood, chips, particles and wood residues. In production, the commodities included are pulpwood. In trade, the aggregate also includes chips or particles and wood residues.
>
> ***Chips and particles*** - Includes wood that has been deliberately reduced to small pieces from wood in the rough or from industrial residues, suitable for pulping, for particle board and fibreboard production, for fuelwood or for other purposes.
>
> ***Other industrial roundwood*** -Includes roundwood used for tanning, distillation, match blocks, gazogenes, poles, piling, posts, pit-props, etc.

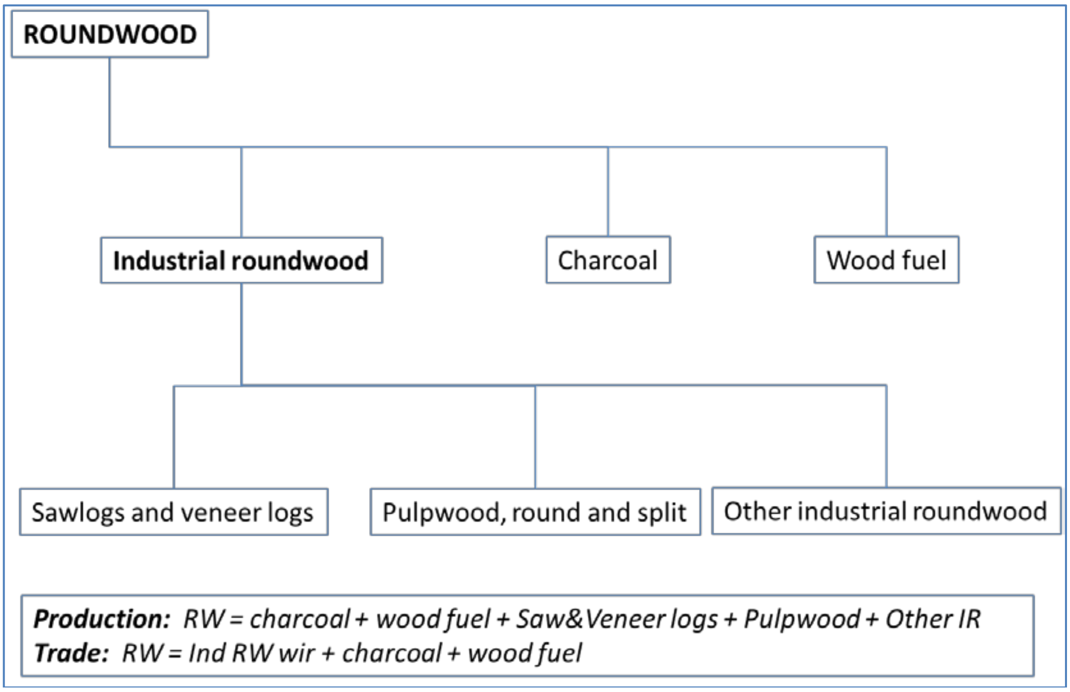

Figure 2. Roundwood classification

The classification scheme for pulp data is given in Figure 3. Note that some pulp is produced from non-wood material, while dissolving pulp is used to make products (e.g. cellophane) that are not included within the paper and paperboard semi-finished product class. Recovered (recycled) paper is included as part of the total fibre furnish.

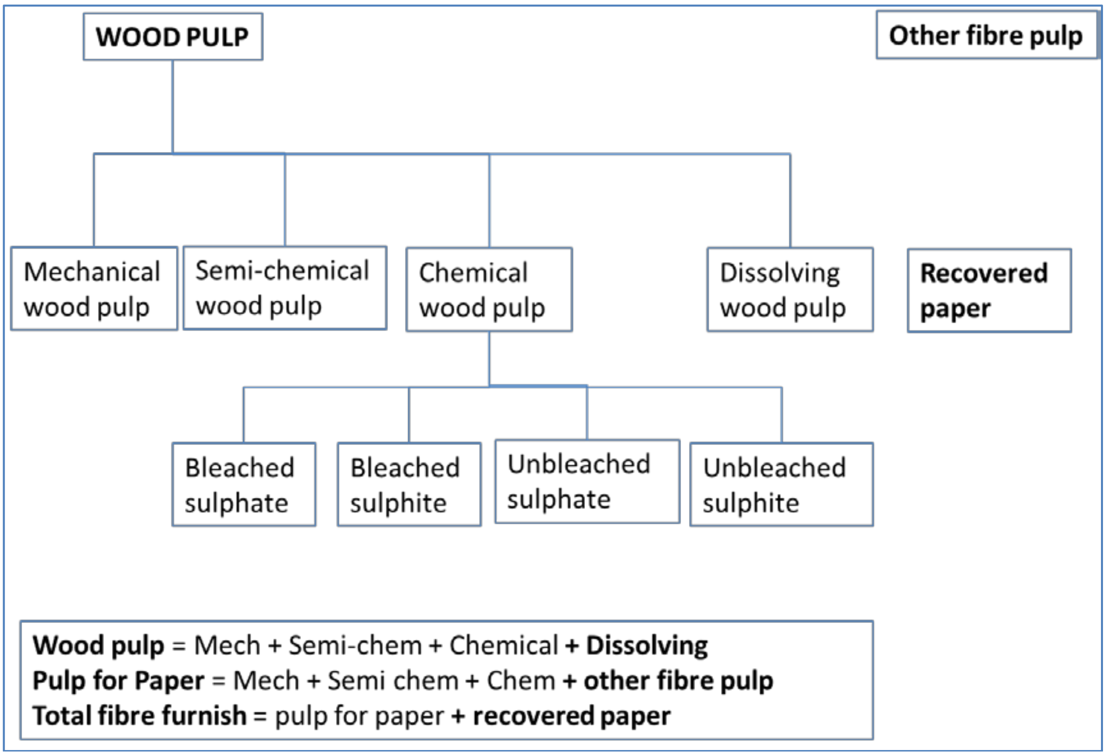

Figure 3. Pulp classification

FAO **sawnwood** is simply divided into coniferous and non-coniferous. It excludes sleepers, and also excludes poles. Post and poles are included within other industrial roundwood.

Wood-based panels comprise plywood, veneer sheets (other than those incorporated into plywood in the country of production), particleboard and fibreboard. The fibre board category has been subdivided into compressed and insulating board, with compressed fibreboard being divided into hardboard and medium density fibreboard (MDF) since 1995 (Figure 3). The veneer sheet category includes veneer used in the construction of laminated construction materials (e.g. laminated veneer lumber, LVL).

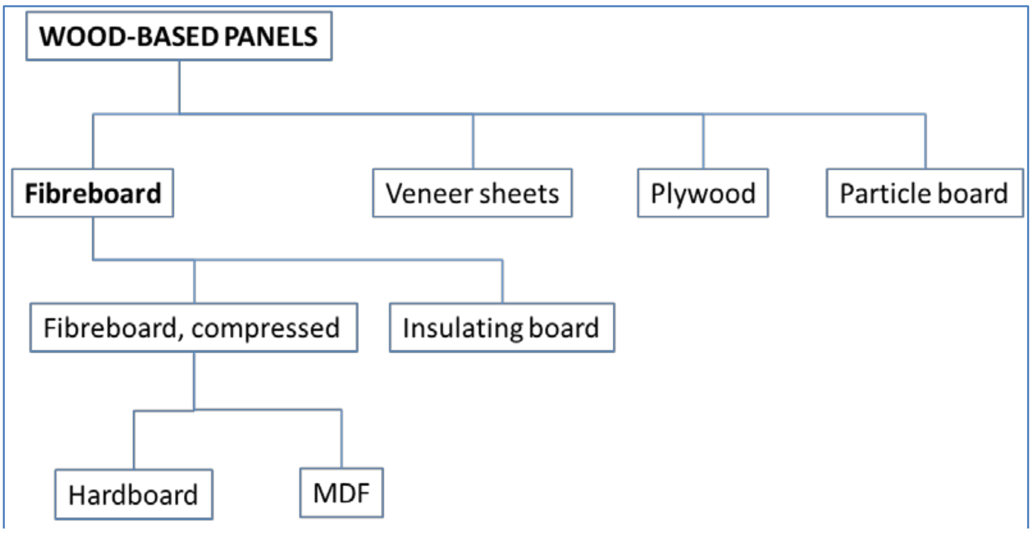

Figure 3. Wood-based panel classification

Paper and paperboard is the final product aggregation, and contains three sub-aggregations of products (Figure 4). Disaggregation of the "Wrapping paper/packaging paper/paperboard" product is available from 1998.

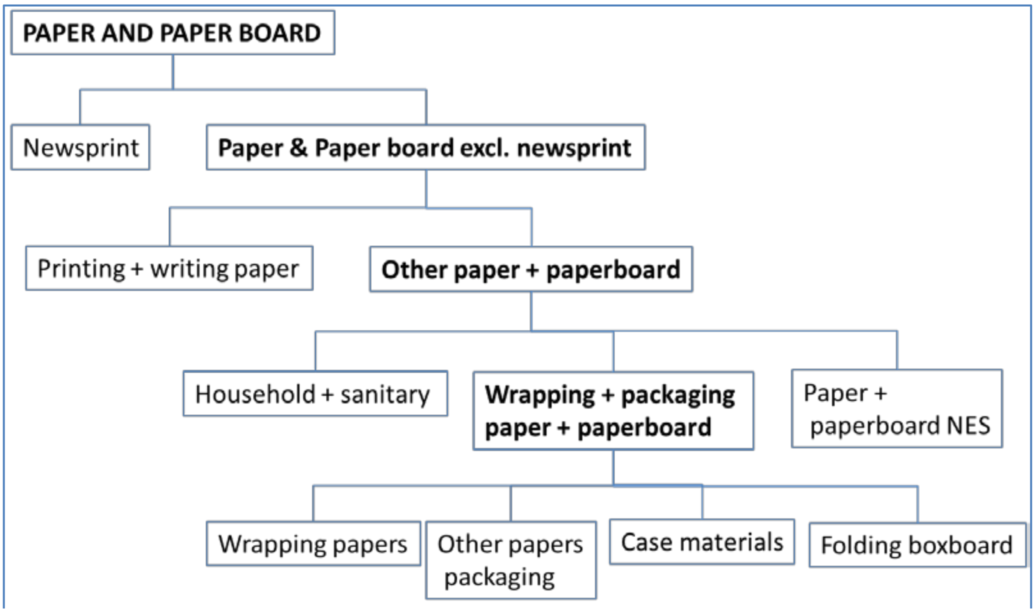

Figure 4. Paper and paper-board classification

Mapping FAO data to IPCC semi-finished product classes

For the vast majority of New Zealand's production of wood products, it is simple to map the FAO-classified products to the three semi-finished HWP classes used for accounting. There are some issues that need particular attention.

Raw materials

Industrial roundwood, wood chips and pulp are not semi-finished products so do not qualify for accounting. This is not an issue for raw materials processed within New Zealand, as the FAO data captures the semi-finished products that are produced. However, carbon exported in roundwood, chips and pulp must be treated as an instant emission at the time of harvest unless there is 'transparent and verifiable' data to capture conversion to semi-finished products in the importing country. FAO does not maintain such data. Allowance also has to be made to exclude carbon in imported raw materials from being included in accounting. New Zealand imports small quantities of logs, poles, sawn wood and panels, and larger quantities of pulp and paper. There is a default approach to exclude imported carbon from accounting which may not accurately reflect the products imported.

Posts and poles

Posts and poles are explicitly excluded from sawn wood which means they are excluded from accounting. They are included within "Other industrial roundwood" which also includes wood used for tanning, distillation, match blocks, gazogenes, pit-props, piles and fencing. While wood used for distillation, tanning and gazogenes can reasonably be excluded from accounting on the same basis as the exclusion of wood fuel, treated posts and poles may have a service life longer than sawn wood so it seems reasonable to include them in accounting. However there are difficulties in tracking their production and trade.

Other industrial roundwood has not been treated as a separate category in FAO trade data since 1997. New Zealand has also combined all export logs within the Other industrial roundwood category in FAO production data – an estimate of pole production has been made to allow this to be disaggregated. Telephone poles are explicitly excluded from the FAO definition of industrial roundwood (wood in rough).

Sleepers

Sleepers have been classified as sawn wood at times in the past[6] but now appear to be excluded. Roundwood includes logs that have been roughly shaped, squared or split, which may include sleepers.

Veneer sheets

Statistics for veneer sheet production exclude veneer sheets that are used in plywood production within the same country – these are captured in plywood production statistics. Exported veneer sheets can be accounted for as plywood, while imported veneer sheets may be used in plywood manufacture (in which case they would have to be netted off domestic plywood production) or the production of finished products (furniture, fittings).

Engineered wood products

Laminated veneer lumber production is included within plywood production and trade statistics. This means it will be treated as a panel product when its use and expected life span is probably more similar to sawn wood. About half of New Zealand's recent plywood production has been laminated veneer lumber according to MPI data. Glue laminated timber (Glulam) is a finished wood product made from sawn timber, so will be captured under sawn wood production. Oriented strand lumber (OSL) is included within oriented strand board so will be treated as a panel product.

Wood chips

Wood chips can be manufactured directly in the forest from roundwood, in which case they are included in the "*Pulpwood, round and split*" product. They can also be made from primary processing residues (e.g. slab wood in a sawmill), in which case they will not have already been accounted for within semi-finished products (e.g. sawn wood). However, they could be made from residues arising in secondary processing (e.g. a mouldings plant), from recycled products or from imported material. For this reason the default accounting approach is to exclude wood chips – they will be captured in panel or paper data if processed in New Zealand.

Bark

Roundwood production is reported as volume inside bark. It can be assumed that bark is not included within semi-finished products but bark is included as part of harvest emissions in the forest model. When calculating the allocation of harvest to HWPs, bark must be taken into account.

IPCC guidance suggests it is good practice to maintain a lower level of aggregation if data are available. A Tier 3 approach could also use finished products. For this report paper and paperboard has been treated as an aggregated product due to the short life span, while the other two products have been disaggregated to improve the conversion of product quantities to carbon.

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[6] http://faostat.fao.org/portals/_faostat/documents/forestproductsdefinitions.htm#4

FAOSTAT PRODUCTION

FAO production data comprises both roundwood and semi-finished product production. Both are obtained from an annual survey sent to countries which is completed for NZ by MPI. MPI estimates quarterly data on roundwood removals from mill out-turns and conversion factors. Annual roundwood removals are estimated for March years based on the same approach for small mills but supplemented with actual log inputs for large mills (Jane Davidson, MPI *pers. comm*).

New Zealand production data was extracted from FAOStat. Production data for semi-finished HWPs can be used directly for accounting, whether exported or used domestically. Total roundwood production is also required to allow HWP production to be calculated as a proportion of the total harvest. This is required for integration with LUCAS reporting. Other production of raw materials is only of interest if they are exported. A possible exception is other industrial roundwood (posts and poles), which could possibly be included in accounting if data are available.

Raw materials production

Appendix III provides a summary of the extracted FAOSTAT data for production of industrial roundwood, wood chips and pulp. Data on posts and poles has been amalgamated with export logs data, so an estimate was made and the data adjusted to enable this to be treated separately.

Semi-finished HWP production

Appendix III provides a summary of the extracted FAOSTAT data for production of sawn wood, wood-based panels and paper and paperboard. Sawn wood has been dominated by coniferous species in the period since 1961. Production from natural forest was dominated by rimu but has declined to an insignificant level. MDF, plywood and veneer sheets make up most of the panel production in recent years, while paper and paperboard production is dominated by newsprint (average 43% of total) and the aggregate wrapping paper, packaging paper and paperboard category (average 45%). Within the latter category, case materials (containerboard) have dominated since 1998 when disaggregated statistics became available.

FAOSTAT IMPORTS

Because some of the production of semi-finished products could have derived from imported raw materials, these need to be excluded from accounting. The IPCC draft guidelines provide a default method for this, though in practice imports make a minor contribution to New Zealand's production of HWPs.

FAOSTAT import data for New Zealand is described in Appendix IV. The default IPCC methodology for determining the contribution to HWPs from domestically grown wood assumes that the raw materials are pulp and industrial roundwood. Domestic production of these raw materials is far greater than imports. Most imported industrial roundwood is likely to be Australian hardwood poles - these are unlikely to be used to manufacture semi-finished products, even at the end of their in-service life span. Residues from discarded imported HWPs and recycled imported paper could also be used in the production of HWPs in New Zealand, but the contribution would be minor.

FAOSTAT EXPORTS

FAOSTAT export data for New Zealand is described in Appendix V. Exports are discussed in more detail here because most of the wood grown in New Zealand is ultimately exported.

New Zealand wood products export sector overview

New Zealand's forestry export industry began with the arrival of the first traders from Australia in the late 1700's. From the 1820's, kauri forests were heavily exploited for the spars favoured by the British navy and then for timber for both domestic use and export to Britain, Australia and California. Timber made up 31% of New Zealand's exports in 1853, before being overtaken by gold and agricultural products. Between 1890 and 1920, 15-25% of all native timber produced was exported (Swarbrick 2012). Paper was largely imported until large-scale pulp and paper mills based on the plantation resource were built in the 1950s.

Due to the abundance of wood, per capita consumption of wood was high and remains so in New Zealand. Despite this there is still a large surplus of supply over domestic demand. This is a result of deliberate policy - while the establishment of plantations in New Zealand in the early 20th Century was aimed at creating a replacement resource for the diminishing natural forest, plantations continued to be established after this was achieved to create an export industry (Roche 1990).

In 1954, roundwood production from planted forests exceeded that from natural forests for the first time and ten years later the value of exported forest products surpassed the value of imports (Roche 1990). Sales of forest products contributed about NZ$4.3 billion in annual export earnings to the year ending June 2012, New Zealand's third largest export sector (*Statistics New Zealand*). The proportional contribution of roundwood removals to the economy is the second highest in the OECD after Estonia (The World Bank, 2013).

It has been estimated that in 2012, 49.4% of New Zealand industrial sawlog production was exported as logs, 65.9% of all wood products processed in New Zealand were exported and overall 82.8% of the harvest is exported (Table 2, Hall et al, 2013).

Table 2: Estimated use of NZ logs in 2012 (log volume equivalent)

	Export			NZ	
	%	Log Vol.		%	Log Vol.
Export Logs	49.4%	13.000			
Export chip	0.60%	0.158			
Sawn Lumber	7.7%	2.026		6.9%	1.816
Plywood	1.0%	0.263		0.6%	0.158
LVL/Veneer	1.9%	0.500		1.4%	0.368
Posts and Poles				0.4%	0.105
MDF	5.4%	1.421		1.0%	0.263
Particle board	0.04%	0.011		0.06%	0.016
Pellets	0.02%	0.005		0.02%	0.005
Mechnical pulp	1.7%	0.447			
Chemical Pulp	11.4%	3.000			
Paper (all)	3.6%	0.947		4.7%	1.237
Sub-Totals	82.8%	21.778		15.1%	3.968
Total				**97.8%**	**25.747**

Carbon reporting and accounting implications of exports

From a carbon accounting perspective, semi-finished HWPs produced in New Zealand and then exported are relatively simple to deal with. By default they can be treated as the same products as those consumed domestically. FAOSTAT provides total product quantities exported from 1961, and New Zealand has additional data dating back to before 1900. Under the IPCC Tier 2 approach, default product half-lives can be assigned. A Tier 3 approach could use specific half-lives for each major export market (as is recommended in draft guidance), and therefore require more detailed knowledge of the end use of export products in the countries in which they are consumed. FAOSTAT can provide data from 1998 on New Zealand exports by importing country and this can be extended to earlier dates using MPI data, although for KP accounting purposes this is not required.

Determining appropriate half-lives for exported HWPs is more difficult, as product end-uses may differ to those for similar material in New Zealand. More difficult still is accounting for roundwood exports. Although FAOStat can provide export log data by market since 1998, and total exports since 1961, roundwood is not an IPCC product class. This means that even if default half-lives are assumed, it is necessary to obtain either:

a) data on the production of sawn wood, panels and paper and paperboard produced from New Zealand-sourced logs in each importing country; or
b) consumption of logs by each mill type, together with information on mill conversion rates and use of residues.

Figure 5 shows a simplified view of Kyoto Protocol accounting for HWPs sourced from New Zealand-grown logs. The sum of annual HWP production enters the HWP pool for accounting. New Zealand's HWP production data can be split into domestic consumption versus exports, to take account of differing applications and half-lives. In practice, some of the exported HWPs are likely to be re-exported, possibly back to New Zealand (e.g. in furniture). Similarly HWPs produced from exported logs may be re-exported rather than used in the importing country. Exported raw materials and semi-finished products are summarised separately in the following sections. More detail is provided in Appendix V.

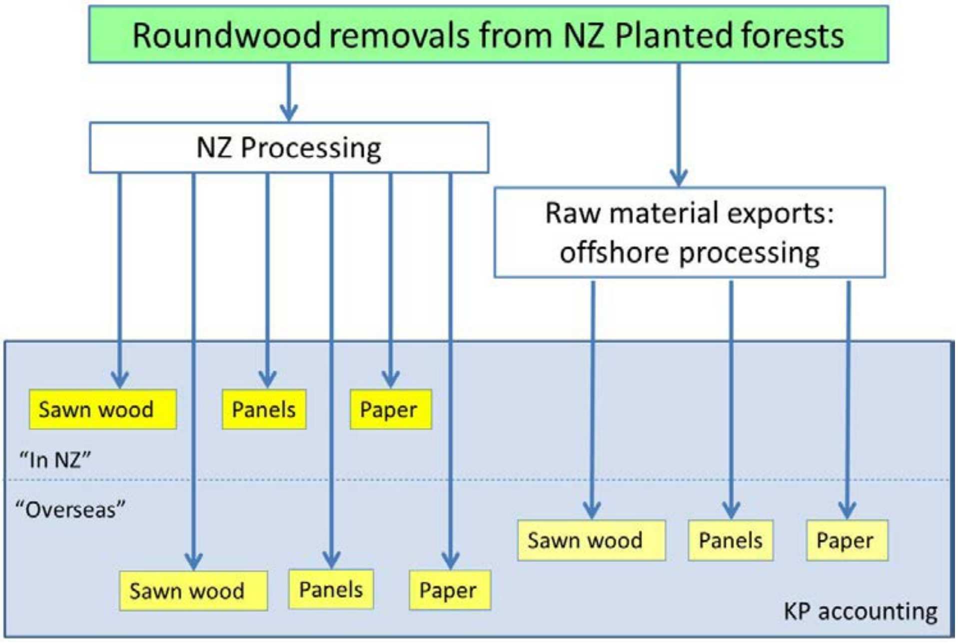

Figure 5: Simplified view of Kyoto Protocol accounting for the second commitment period. All HWPs produced from New Zealand-grown wood may potentially be accounted for by New Zealand if data is available.

Exported raw materials

Raw material exports include logs, wood chips and pulp. In the absence of market-specific data on semi-finished HWP production by raw material source country it is necessary to apply raw material-to-product mill conversions.

In 2011 51% of pulp produced in New Zealand was exported. It is reasonable to assume that exported pulp will be converted to paper. Traditionally the main market was Japan, but now China (32%), Korea, Japan, Australia and Indonesia account for 80% of pulp exports. There is little global variation in the conversion of pulp to paper, so estimating paper and paperboard production is relatively straightforward.

Chips can be used to make both panels and pulp for paper production, but it is reasonable (and conservative) to assume that chips exported from New Zealand will be used in paper-making. Chips that are produced from HWPs (e.g. timber waste from a remanufacturing plant) must not be included to avoid double counting. Chip exports began in 1969 and Japan has been the only significant market. Hardwood chips from natural forests were exported in the past but this practice has stopped.

Half of New Zealand's harvest is exported in log form, with China, Korea, India and Japan accounting for almost all of the trade. Exported logs can be used as poles, sawn, peeled or sliced for veneer, chipped for panels, or converted to pulp. Some of these processes generate residues that can be used to make panels or paper. This makes it much more difficult to estimate conversion to semi-finished products.

Conversion of exported raw materials to semi-finished HWP categories is discussed in Appendix VI. The conversion factors in Table 3 were used to estimate the amount of HWPs produced, with residues allocated as in Table 4. These estimates are nominal but can be set for each market and year within the model. An alternative scenario allocates exported logs according to domestic production proportions – this default allocation is allowed for Convention reporting but not for KP reporting.

Table 3. Assumed mill conversion factors (HWP output per log input)

	Sawmill	Panel mill*	Paper mill
Japan*	0.60	0.55 + 0.15	0.66
Korea	0.55	0.55 + 0.15	0.66
China	0.55	0.55 + 0.15	0.66
India	0.50	0.50 + 0.10	0.66
Other	0.50	0.50 + 0.15	0.66

* plymill conversion + residues to other panel mills

Table 4. Assumed residue use (allocation to secondary HWP as % of input to primary mill)

	Sawmill to panels	Sawmill to paper	Plymill to panels	Plymill to paper
Japan	0.10	0.10	0.15	0.10
Korea	0.15	0.10	0.15	0.10
China	0.15	0.10	0.15	0.10
India	0.10	0	0.10	0
Other	0.15	0.15	0.15	0.10

Exported semi-finished HWPs

In 2011 52% of sawn wood, 49% of panels, and 72% of paper/paperboard produced in New Zealand were exported. However, exports of semi-finished products have been relatively stable over the past decade, not matching the huge increase in the exports of logs.

FAO bilateral trade data exists from 1997 but main export markets are identified from 1900. Australia was originally by far the main market for sawn timber, taking well over 90% for much of the time series. The sawn timber market is much more fragmented now and while Australia still holds the top position it takes just 22%. China, USA, Vietnam, Korea, Japan, Thailand, Taiwan and Indonesia are the next largest markets.

Exports of panels and paper began later, with the development of major pulp and paper mills in the 1950s and MDF production in the 1980s. Japan takes about half of the panel exports – together with Australia, the Philippines, China, Indonesia and Vietnam they account for about 80% of exports. MDF is the main product exported. Australia is still the main destination for paper, taking 45% of exports. China, the Phillipines, Malaysia, Hong Kong, Korea and Taiwan follow.

End uses vary by country and do not necessarily correspond to New Zealand practices. Timber-framed houses typical of New Zealand, Australia, North America and Western Europe are less common in Asia, and radiata pine does not meet the requirements for traditional wooden housing in Japan. This is an issue when assigning half-lives that are appropriate to the importing country.

BACKFILLING DATA TO 1900

Default data backfilling process

The IPCC provide a default back-casting method to allow data to be obtained for 1900 to 1960. This allows changes to the HWP pool to be estimated from 1990, including ‘inherited emissions’. This is not required for Kyoto Protocol accounting purposes, which takes into account only HWPs produced from 2013 (or 1990 for post-1989 forests).

A variable (***U***) is used to represent the constant rate of change in industrial roundwood consumption between 1900 and 1961.[7] For the Oceania region the default value of U is 0.0231, i.e. an annual growth rate of 2.31 per cent.

Equation 1 (from equation 12.6 in the *2006-Guidelines*) shows how production, import or export variables before 1961 can be estimated:

Equation 1. $$V_t = V_{1961} * e^{[U*(t-1961)]}$$

Where:
V_t = annual production, imports or exports for a solidwood or paper product for year *t*, Gg C yr^{-1}
V_{1961} = annual production, imports or exports for a solidwood or paper product for the year 1961, Gg C yr^{-1}
U = estimated continuous rate of change in industrial roundwood consumption for the region that includes the reporting county between 1900 and 1961, yr^{-1}
t = year

Application of the equation leads to an increasing value for each product from 1900 until the 1961 data point is reached.

Country-specific backfilling process

While the backfilling process is only intended to provide indicative data, it is particularly unsuitable for New Zealand due to the relatively short history of industrial forestry in New Zealand. The nature of forestry changed dramatically between 1900 and 1961, from a reliance on natural forests and imports to an increasingly export-oriented industry based on a plantation resource. For example:

- Sawn timber was exported extensively throughout the post-1900 period
- Wood-based paper was not produced in quantity until the 1950’s
- Export of logs, pulp, paper and panels did not begin until the 1950’s.

Data was obtained from MPI and New Zealand yearbooks to provide an alternative to the default approach. This is discussed in more detail in Appendix VII. An example is provided here for illustrative purposes (Figure 6). Clearly exports of sawn timber from 1900 to 1960 were not a function of New Zealand’s population growth or 1950-1975 harvest rates, as assumed buy the *U* variable. However, it should be remembered that pre-2013 HWP data is not used for Kyoto accounting purposes, and is only used in UNFCCC inventory reporting to estimate lagged emissions from the pool of HWPs produced before 1990. By 1990 much of the carbon in HWPs is assumed to have already been emitted.

[7] Regional defaults have been derived by combining a documented actual rate of change from 1950 to 1961 and an estimated rate of change from 1900 to 1950. The estimated rate from 1900 to 1950 is formed by adding together the annual percent change of population growth from 1900 to 1950 and one half the annual percent change in industrial roundwood harvest per capita for the period 1950 to 1975. Population growth rates over the relevant period for Australia and New Zealand have been similar (1.7% New Zealand versus 1.6% Australia) so the Oceania default rate is reasonable.

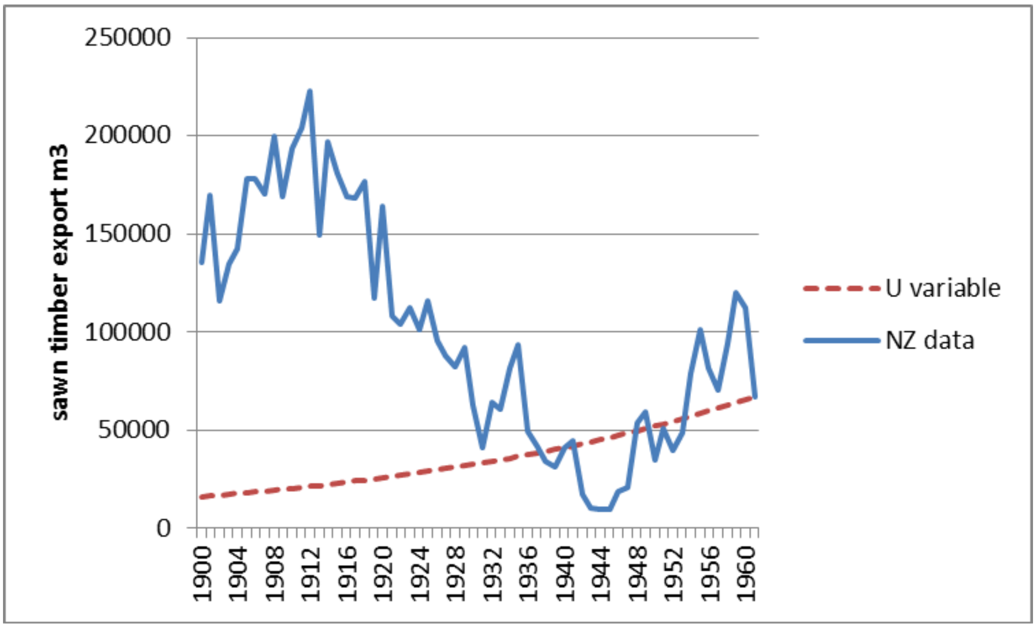

Figure 6: New Zealand 1900-1960 sawn timber exports compared with U variable estimate.

DATA PROJECTIONS TO 2020

To estimate the impact of the HWP accounting provision on New Zealand's balance of units for the second commitment period, it is necessary to project production, imports and exports of HWPS from 2013 to 2020. A more reasonable approach is to examine trends to determine the likely allocation of harvest to the three products.

New Zealand's wood availability is expected to increase slowly from 2013 then more rapidly towards the end of the decade, as a consequence of the age class distribution. Wood availability forecasts were made by MPI for regions within New Zealand in 2007-2010. Projections were made under a number of scenarios that varied in how much the harvest is smoothed, with the harvest during CP2 being largely determined by harvest intentions supplied by the large forest owners. The actual harvest will depend on decisions made by hundreds of forest owners, with prevailing market conditions being one key influence. There may also be domestic harvesting, logistics and processing capacity constraints that limit the increase in harvesting. The harvest projection underlying New Zealand's FMRL is shown in Figure 7 together with alternative wood availability forecast scenarios from MAF (2010). The harvest could increase by about 10 million m^3 by 2020.

Domestic demand is not expected to greatly increase during CP2, so most of the increase in harvested volume must be exported, either as logs or harvested wood products. The Wood Council of New Zealand (Woodco) has developed a strategy aimed at doubling the value of forestry sector exports by 2022 by increasing processing in New Zealand. There is unutilised sawmilling capacity to process an extra 1 million m^3 in New Zealand (Hall et al 2013b) but beyond that more investment in processing would be required. There would also need to be demand for processed products in export markets.

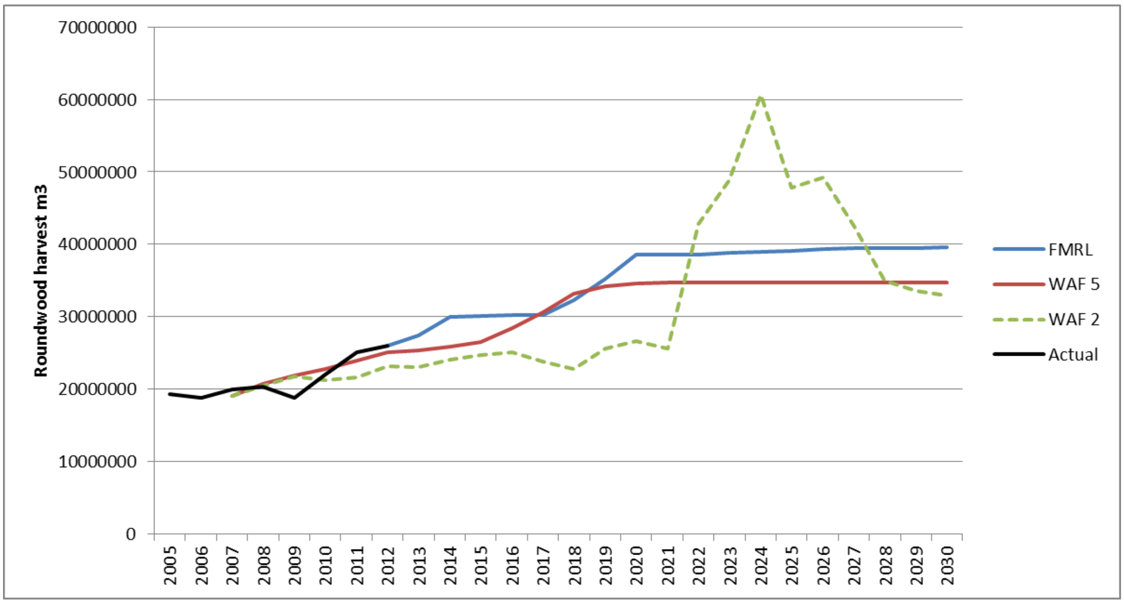

Figure 7. Harvest projections in New Zealand's Forest Management Reference Level (FMRL) for Kyoto Protocol second commitment period accounting compared with two Wood Availability Forecast (WAF) scenarios.

Key factors relevant to New Zealand's wood export prospects are:

1. Excess demand over supply in India and China;
2. Russian far east softwood supply issues
3. Recovery in the US housing market and other western economies.

The strong demand for raw logs from China and India is likely to continue due to the relatively strong economic growth in these countries. In contrast, demand in Korea is expected to be relatively flat while Japanese demand will continue to fall. MPI (2013) identified that logistics constraints are starting to increase costs for New Zealand exporters.

Russian larch competes with radiata pine but supplies have been reduced for several reasons, including the imposition of an export tax, reduction in road building subsidies, diminishing supply of easily accessible wood and a lack of investment in infrastructure. Supply has been diverted from Europe and North America markets due to the downturn in the economy. Europe has replaced New Zealand as the biggest supplier of sawn timber to Australia and excess US supply is being sent to Asia while the US housing market recovers. There are now signs that Canadian exports are being redirected to the USA as the market there recovers.

Conditions for New Zealand sawn timber producers are difficult, with reduced demand in Australia and New Zealand, increased competition and a high New Zealand dollar. Demand for fibreboard is high but plywood faces competition from China. World pulp markets are weak, leading to reduced newsprint production in New Zealand.

A business-as-usual projection would see the proportion of the annual harvest exported in log form continue to increase. Exports of sawn wood and panels would be relatively stable while pulp and paper exports decline.

PRODUCT TO CARBON CONVERSION

IPCC Default carbon conversion factors

The carbon content of HWPs can be estimated from the default factors provided in the draft guidance (Table 5).

Table 5. Default conversion factors for the default HWP categories and subcategories

	Oven dry density* (t m-3)	**Carbon fraction**	**C conversion factor (t C m-3)**
Sawn wood aggregate	0.458	0.5	0.229
Sawn wood(C)	0.45	0.5	0.225
Sawn wood(NC)	0.56	0.5	0.280
Veneer Sheets	0.505	0.5	0.253
Plywood	0.542	0.493	0.267
Particle Board	0.596	0.451	0.269
Fibreboard, Compressed	*0.739*	*0.426*	*0.315*
Insulating Board	0.159	0.474	0.075
Hardboard	0.788	0.425	0.335
MDF	0.691	0.427	0.295
Panels (aggregate)	*0.595*	*0.454*	*0.269*
	Mg/Mg		**Mg C/Mg**
Paper	0.9		0.386

* air dry density for paper

In this table, aggregate sawn wood density is a weighted average based on global FAO data, veneer density is based on an equal contribution from coniferous and non-coniferous wood and compressed fibreboard is based on an equal share between high density fibreboard (HDF) and MDF. It is good practice to replace these factors with country-specific data if available.

New Zealand-specific carbon conversion factors

The carbon content of a HWP is derived from the carbon fraction and the basic density of the HWP. These two parameters are multiplied to produce the carbon conversion factor for each HWP sub category. The carbon content of wood is relatively constant. Measurements have found that wood is approximately 48-52% carbon with minor variation between species (Birdsey, 1992). The IPCC default of 50% is commonly used and has been retained for consistency with the forest model. However, wood density is much more variable and HWPs differ greatly in terms of how much wood material is incorporated within a given volume.

Basic density

New Zealand plantation grown radiata shows considerable variation in wood density – between and within stands and trees. Variation in outer wood density is shown in Figure 8. Cown et al (1991) estimated the mean whole stem basic density for radiata pine in New Zealand as 380 kg/m^3 (range 330-450). A whole tree density range from 320-520 kg/m^3 in exported radiata logs has been reported (McConchie et al., 1990). This variability can be attributed to siting, wood age at harvest, genotype, and forest management practices especially stocking rate (Cown & McConchie, 1981; McConchie et al., 1990).

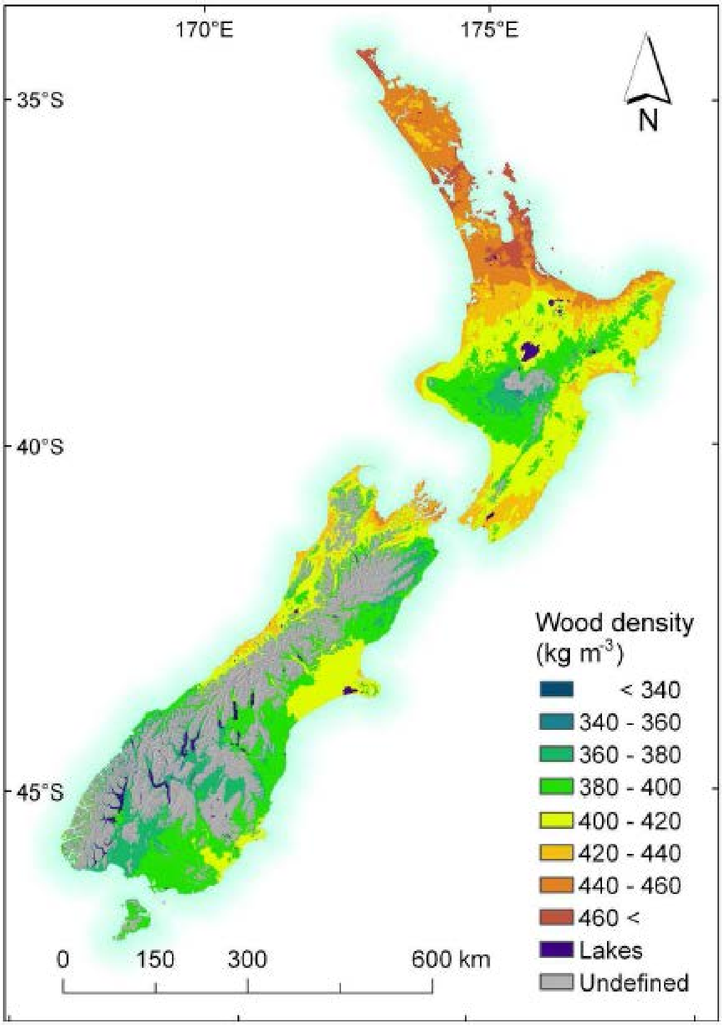

Figure 8: GIS Surface map of predicting the spatial variation in outer wood density of radiata across New Zealand (from Palmer et al. (2011)

Kibblewhite (1984) reported a range in chip basic density of 288-540 kg/m^3 for radiata pine chip samples taken from whole tree thinnings, and old and new crop slabwood and corewood. Clearwood sawn from the outer growth rings of mature trees in some regions may have a density in excess of 500 kg/m^3, while sawn corewood may have a density that is over 30% lower.

The IPCC default coniferous wood density value of 450 kg/m^3 is at the higher end of the whole tree density range for New Zealand radiata pine. The value of 420 kg/m^3 reported by Jones (2005) is more appropriate but may also be too high. The mean density of harvested radiata varies over time as the harvest proportions by age, region and management change. A higher proportion of the post-1989 planted forests are on fertile ex-farm sites, which have lower density.

A network of plots have been established in pre-1990 and post-1989 forests for carbon reporting purposes, and model simulations have been run for each plot to estimate carbon by pools over a whole rotation for each plot. This includes estimates of wood density modelled from site fertility, density and stocking. Mean outer wood density at age 28 was estimated as 386 kg/m^3 for 201 post-1989 plots, and 413 kg/m^3 for 189 pre-1990 plots. Whole tree density is typically 90-95% of this, giving an estimate of 373-394 kg/m^3 for pre-1990 forests which are expected to provide most of the harvested roundwood during CP2. These are under-estimates because a proportion of the plots are non-radiata pine species which are typically harvested at older ages when higher density would be expected. The mean outer wood density value estimated for pre-1990 radiata pine plots at age 28 was 415 kg/m^3, equivalent to 374-395 kg/m^3 whole tree density. For this report a radiata pine mean whole tree density estimate of 420 kg/m^3 was used with 380 kg/m^3 used as an alternative scenario.

While radiata pine dominates production now, a different carbon factor is required to accurately estimate carbon in imports and over the historic time series when a range of species were harvested and exported. For exports this mainly affects sawn timber, because exports of other HWPs and logs did not begin until radiata pine was dominant. A time series of sawn timber production by species was used to estimate weighted basic density. Production by species is shown for part of the time series in Appendix III and the historic data is described in Appendix VI. Basic density by species is given in Table 6.

Table 6: Basic density by New Zealand-grown species

Species	Period	Oven dry density odt/m^3
Kauri	1900-2011	0.48
Rimu	1900-2011	0.49
Kahikatea	1900-2011	0.39
Matai	1900-2011	0.54
Totara	1900-2011	0.41
Beech	1900-2011	0.49**
Radiata pine	1900-2011	0.42*
Other species	1900-1950	0.42**
Tawa	1951-2011	0.58
Other native hardwood	1951-2011	0.49**
Other pines	1951-2011	0.42**
Larch	1951-2011	0.45
Douglas fir	1951-2011	0.40
Macrocarpa	1951-2011	0.40
Other plantation softwoods	1951-2011	0.40**
Eucalyptus spp	1951-2011	0.50**
Poplar	1951-2011	0.38
Other plantation hardwood	1951-2011	0.50**

Source: Jones (2005) except:
* base estimate assumed for this report. ** assumed.

Estimated weighted wood density is shown in Figure 9, with a clear trend from the 1940's of decreasing density before stabilising close to the assumed radiata pine density level. These assumptions can be changed in the model. Wood density is therefore more important for the historic time series used for UNFCCC reporting and less of an issue for Kyoto CP2 estimates.

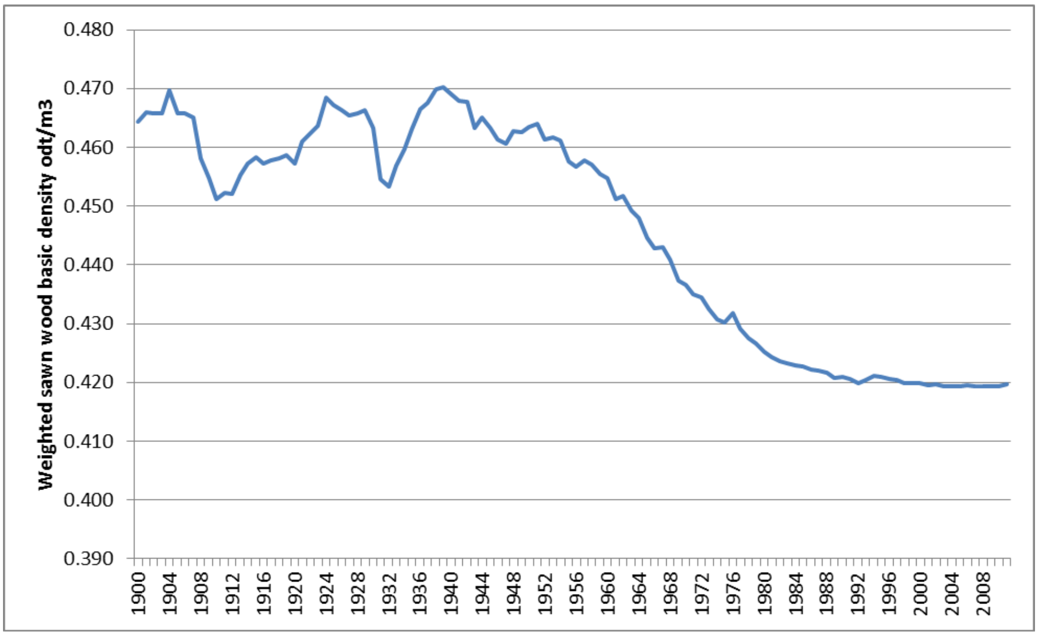

Figure 9: New Zealand sawn timber weighted average basic density

Import data by species was used to estimate weighted density of sawn timber imports for the period 1971-2011. The main species imported (with their assumed basic densities in kg/m3) were: Douglas fir (460), redwood (450), cedar (370), other softwoods (420), Eucalyptus species (620), oak (700), tropical hardwoods (750) and other hardwoods (700). This analysis suggested that imports were a relatively even mix of softwoods and hardwoods and a constant density of 550 kg/m3 would be appropriate. More details are in Appendix VI.

Product density and carbon fraction

Product density ranges reported by Warnes (2005) are similar to the IPCC defaults: Plywood 540-550 kg/m3 (c.f. 542), particle board 500-700 kg/m3, (c.f. 596), hardboard 700-1100 (c.f. 788), softboard 300, and MDF 600-740 (c.f. 691). Manufacturer websites (such as Daiken[8] and Laminex[9]) show the great range in the density in panel products produced in New Zealand. The weighted-average density of the annual production of each panel product in New Zealand is unknown so the IPCC defaults for product density and carbon fraction have been retained.

Pulp and paper are measured in air dry tonnes, at 10% moisture content. There is a substantial difference in carbon content between pulp produced by chemical pulping and mechanical pulping due to the removal of in the chemical pulping process (Smook, 1982). The overall carbon content of mechanical pulp is 0.45 t C per adt (90% of 0.5). In chemical pulp, the lignin has been removed so the carbon content is lower, giving an overall carbon content of 0.3996 t C per adt (90% of 0.444). Pulp produced in NZ using radiata feedstock via a kraft chemical pulping process was measured as containing 0.399 t C/adt (Ellis and Allison 1992). For production and exports, a 50:50 split between mechanical and chemical pulp was assumed giving a carbon fraction of 0.425 t C/adt. For imports, the chemical pulp value was assumed.

[8] http://www.daiken-nz.com/assets/images/downloads/Daiken-All-Markets-Specifications.pdf
http://www.daiken-nz.com/assets/images/downloads/Daiken-NZ-AUS-Specifications1.pdf
[9] http://tradeessentials.thelaminexgroup.com.au/uploads/tech-info/TLG892%20TE%20Plywood%20Brochure%208-12A-1lowres.pdf

The carbon content of paper varies – the IPCC default is 0.386 per air dry tonne, which is equivalent to 0.428 t C per oven dry tonne. Given the short life span of paper and paperboard this default value was accepted. New Zealand-specific factors are given in Table 7 – other factors used were as in Table 6.

Table 7. Country-specific conversion factors for HWP produced in New Zealand

	Oven dry density* (t m-3)	**Carbon fraction**	**C conversion factor (t C m-3)**
Sawn wood (composite)*			
Sawn wood(C)	**0.42**	0.5	**0.210**
Sawn wood(NC)	**0.50**	0.5	**0.250**
Veneer Sheets	**0.42**	0.5	**0.210**

* an annual weighted-average density estimate is also available in the spreadsheet model

DOMESTIC ORIGIN PROPORTION

To be eligible to enter the accounting system, HWPs must be produced from logs harvested from domestic forests that are included in a country's accounting. The IPCC draft guidelines propose a default approach to enable carbon from imported wood materials to be excluded from accounting. This involves estimating the proportion of feedstock that derives from domestically harvested wood, and then applying this to the HWP production, as in Equation 2 and Equation 3:

Estimation of annual fraction of feedstock for sawn wood and panel production originating from Domestic Harvest:

Equation 2

$$fIRW(i) = \frac{IRWp(i) - IRWEX(i)}{IRWp(i) + IRWIM(i) - IRWEX(i)}$$

Where:

fIRW(i) = share of industrial roundwood for the domestic production of HWP originating from domestic
forests in year *i*.
IRWp(i) = production of industrial roundwood in year *i*, Gg C yr-1
IRWIM(i) = import of industrial roundwood in year *i*, Gg C yr-1
IRWEX(i) = export of industrial roundwood in year *i*, Gg C yr-1

Estimation of annual fraction of feedstock for paper and paperboard production originating from Domestic Harvest:

Equation 3

$$fPULP(i) = \frac{PULPp(i) - PULPEX(i)}{PULPp(i) + PULPIM(i) - PULPEX(i)}$$

Where:
fPULP(i) = share of domestically produced pulp for the domestic production of paper and paperboard in year *i*.
PULPp(i) = production of wood pulp in year *i*, Gg C yr^{-1}
PULPIM(i) = import of wood pulp in year *i*, Gg C yr^{-1}
PULPEX(i)= export of wood pulp in year *i*, Gg C yr^{-1}

The equations for calculating the annual HWP amounts being produced from domestic harvest related to activities under Article 3.3 and 3.4 are:

Equation 4 **Sawn wood and Panels:** $HWPj(i) = HWPp(i) \bullet fIRW(i) \bullet fj(i)$

Equation 5 **Paper:** $HWPj(i) = HWPp(i) \bullet fIRW(i) \bullet fPULP(i) \bullet fj(i)$

With fIRW(i) = 0 fIRW(i) < 0 and fPULP(i) = 0 if fPULP(i) < 0

HWPj(i) = HWP amounts being produced from domestic harvest associated with activity j in year *i*, in m^3 or Mt yr^{-1}
HWPp(i) = production of the particular HWP commodities in year *i*, in m^3 or Mt yr^{-1}
Fj(i) = share from forests accounted for under Articles 3.3 or 3.4 (i.e. excluding HWPs from non-forest origin). Fj(i) is discussed in the next section.

Under this default approach, almost all of New Zealand's annual sawn wood and panel production would be accountable (average of 99.97% over the last five years). For paper and paperboard, the product of fIRW and fPULP is used, resulting in a 97.47% domestic share over the last five years.

Note that it is assumed that the raw material inputs used to produce sawn wood and panels are also assumed to be potential inputs to the paper-making process, as well as imported pulp. This is likely to over-estimate the contribution of imports to HWP production. A high proportion of imported logs are durable Australian hardwood sleepers and poles which are not likely to be processed into HWPs and unlikely to generate residues that are used to make paper. An alternative domestic origin scenario was modelled in which no imported logs are converted into sawn wood, panels or paper and no imported panels or sawn timber are converted into pulp. Thus fIRW = 1, and the domestic share for paper is given by fPULP alone, which assumes that pulp is the only imported material used for domestic papermaking. This has little impact on the domestic share for paper and paperboard because the value for fIRW is already close to 1.

ALLOCATION OF ROUNDWOOD PRODUCTION TO HWPS BY ACTIVITY

For UNFCCC reporting, all domestically grown HWPs are aggregated and treated in the same way. In contrast, accounting rules differ for HWPs under the second commitment period of the Kyoto Protocol depending on the activity from which they originate. National roundwood production statistics do not distinguish between the alternative sources.

HWPs from non-forest origin

Logs extracted from the forest are treated as an instantaneous emission at the time of harvest in the forest model, so the purpose of the HWP model is to reinstate and track the harvested carbon that is incorporated into qualifying HWPs. Since carbon in HWPs derived from non-forest sources was not accounted for as an emission at the time of harvest, it cannot be 'reinstated'. For example, shelterbelts surrounding perennial crops and the crop trees themselves are classified as "Perennial Cropland" rather than forest. New Zealand chose not to account for Cropland Management as an elective Article 3.4 activity, so no stock change in Perennial Cropland enters accounts. Any HWPs produced from perennial cropland trees would represent an instantaneous gain of carbon in the HWP pool, so they must be excluded.

Roundwood production statistics do not differentiate between forest and non-forest sources. In practice contributions from outside Forest land would be very small. Tree felled on farmland are likely to be used for on-farm purposes including firewood, and therefore not enter into national HWP production statistics.

HWPs from deforestation

HWPs resulting from deforestation must be accounted for as an instantaneous emission. There is likely to be deforestation of both post-1989 and pre-1990 forest during the second commitment period. This could include immature stands that are used for bioenergy as well as mature stands where land use change takes place after a normal harvesting event. It is also possible but unlikely that HWPs could arise from deforestation of pre-1990 natural forest.

HWPs from harvesting

Harvesting during CP2 will be dominated by pre-1990 planted forests, with only a small amount of harvesting in post-1989 planted forests and pre-1990 natural forests. Accounting for pre-1990 forests is against the Forest Management Reference Level, so changes in the HWP pool need to be incorporated as a technical correction.

Allocation to activity methodology

The default methodology involves estimating **fj(i)** - the share from forests accounted for under each activity. Draft guidance suggests this be calculated from harvest estimates. The approach take here is to instead calculate the proportion of Roundwood Production allocated to each HWP, and then apply this to estimates of harvest and deforestation emissions made in the forest model (LUCAS CRA module). In this way HWPs from non-forest sources are automatically excluded ($f_{non\text{-}forest}(i) = 0$).

Estimates of above-ground carbon loss were obtained from LUCAS (Nigel Searles, MFE *pers comm*). It was assumed that 70% of the AGB loss was in logs removed from the forest (the proportion assumed for harvest losses in the national greenhouse gas inventory, MFE (2012)). The share of each activity is shown in Figure 10. Note that no estimates of losses from natural forest harvesting or deforestation were available from LUCAS. Given the expected continuing low level of natural forest harvesting (about 0.01% of the total harvest) this does not introduce a significant error during CP2.

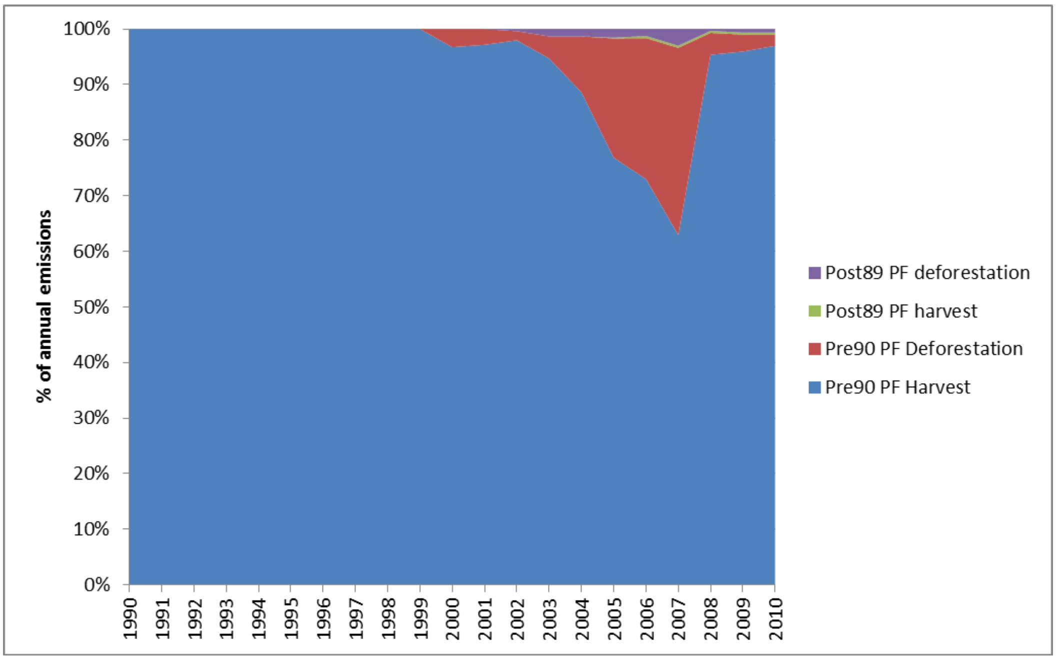

Figure 10. Proportion of above-ground biomass carbon losses by activity

These proportions can be used as the values for fj(i) in Equation 4 and Equation 5, allowing the domestic share of HWP production to be allocated to activities. With this approach, it will be assumed that each activity produces the full range of HWPs in the same proportions. A refinement would be to ensure that harvesting or deforestation of post-1989 forest only or mostly produced paper. Given the minor contribution from this source there would be little impact. It is assumed that deforestation of pre-1990 planted forests has in the past and will continue to take place at the end of a normal rotation, with the same product mix produced on average as for harvesting.

HWP HALF-LIVES AND FIRST ORDER DECAY

First order decay function

Changes in carbon stocks in each pool are estimated by the first order decay function described in equation x. The carbon stock in a given year is calculated as a function of the stock at the beginning of the previous year and a decay constant, derived from the half life assumed for the pool.

ESTIMATION OF CARBON STOCKS AND ANNUAL CARBON STOCK CHANGES IN HWP POOL OF THE REPORTING COUNTRY

Equation 6 $\mathbf{C(i+1) = e^{-k} . C(i) + [(1-e^{-k})/k] . Inflow(i)}$

$\Delta C(i) = C(i\_1) – C(i)$

Where
I = year
C(i) = the carbon stock in the particular HWP category at the beginning of the year I, Gg C
K = decay constant of first order decay for HWP category given in units year-1 (k=ln(2)/HL, where HL is half life of the HWP pool in years
Inflow(i) = the inflow to the particular HWP category during the year I, Gg C yr-1

The decay function is assumed to implicitly capture discards of the finished products produced from the semi-finished HWP categories as well as any losses from the pool due to secondary processing. It does not necessarily describe the return of carbon to the atmosphere, but rather the amount of carbon that migrates out of the product in-service pool to another pool. For wood products these other pools could be where HWPs are potentially burned, composted or transferred to solid waste disposal where they either decay or remain indefinitely.

Default half lives

The half life is the number of years it takes to lose one half of the material currently in the pool. Decision 2/CMP.7 provides default half lives for the three semi-finished product categories: 35 years for sawn wood; 25 years for panels; and 2 years for paper. Under a Tier 2 approach, these half lives may be used for both domestically consumed and exported HWPs. However, countries are encouraged to use separate country-specific half lives.

Country-specific half-lives for HWPs

There is limited data on the in-service life spans of HWPs within New Zealand. Since about half of New Zealand produced HWPs are exported, the life span in export markets is just as important. In practice, HWPs exported to a market (or produced there from logs imported from New Zealand) are not necessarily consumed within that market. For example, panels and timber used within the Chinese furniture industry are likely to be re-exported. In addition, sawn timber from the higher quality logs processed in New Zealand and exported is likely to have a different end use than sawn timber produced from industrial grade export logs. The options for assigning half-lives include:

- Use the IPCC defaults in all markets;
- Use country-specific default half-life in each market, as used by each country;
- Use specific in-market half-life for HWPs made from NZ-grown wood.

A review of the literature revealed a significant disparity in reported half-lives for common wood products (Table 8). The range for sawn timber (18-50 years) is significantly larger than the range for paper products (0.5-10 years). Variation may be due to species, market dynamics (Lauri et al., 2013), and financial and geopolitical landscape (Goh et al., 2013; Schwarzbauer et al., 2013). The half-life must capture not only the potential longevity of products but also ‘premature’ discards due to obsolescence or changes in fashion. Allocating an in-use half-life to products is further complicated by country-specific product terminology and uses. For example the use of logs as mushroom substrate is not as common in the European Union as it is in Japan.

Table 8: Reported product half-lives.

Primary product Half-life (years)	Hashimoto and Moriguchi (2004)	Pingoud et al. (2001)	Karjalainen et al. (1994)	Pingoud et al. (1996)	Nabuurs (1996)	Skog and Nicholson (2000)	IPCC (2003)	IPCC (2011)
Sawn Wood								
Sawn wood		30	50			40	35	35
Veneer, plywood and structural panels						45	30	
Non-structural panels						23	20	
Wood Panels								25
Building	45							
Particle Board					20			
Sawn wood (spruce and poplar)					18			
Sawn wood (oak and beech)					45			
Paper								
Paper	1.25			1.8	2		2	2
Paper (mechanical pulp)			7					
Paper (chemical pulp)			5.3					
Newspaper sanitary paper				0.5				
Liner board fluting and folding boxboard				1				
80% of printing and writing paper				1				
20 % of printing and writing paper				10				
Paper “free sheet”						6		
Other Paper						1		
Other								
Packing wood					3			
Infrastructure	45							
Other wood products	5							
Mushroom bed log	3							
Packing and pallet	5							
Furniture and household goods	10							

Half lives for New Zealand

Radiata pine is notable for the diverse range of potential end product uses so it particularly difficult to accurately estimate life-spans. One of the advantages of radiata pine over comparable softwoods is that is can be readily treated. Predicted average service lives from field tests on treated poles are 70-90 years, or over 100 years for H6 treatment with higher chemical retention rates (Scion unpubl. data).

Previous attempts to estimate in-use half-lives for New Zealand HWPs have been based on experience-based assumptions or estimates. Buchanan and Levine (1999) reviewed the international literature then assigned half lives for New Zealand products of 1 year for fuel wood, 3 years for paper and 40 years for solid wood. Maclaren and Wakelin (1991) attempted to categorise wood products by their longevity, attributing an 80 year life-span to posts and poles, a 50 year half-life to medium term uses such as building and furniture products, and a one year half life for paper and sawn wood and panels used in packaging and concrete formwork. The weighted average for all solid wood was estimated to be a little over 31 years. Similarly Ford-Robertson (2003) categorises wood products by life-span into 50, 20 and 1 year categories in an illustrative implementation of the Simple Decay approach. Page (2007) modelled demolition rates for houses by assuming life spans for houses of 85 to 110 years, depending on the decade in which they were built. Manley and Maclaren (2010) used the IPCC default half lives but cautioned that the IPCC HWP categories were arbitrary, the range in reported half lives was wide, hard data pertaining to New Zealand was unavailable, and assumptions relevant to New Zealand may not apply in export markets. These points are still valid, making it hard to justify any proposed alternative to the IPCC default half lives for HWPs in New Zealand as an improvement.

Half lives in export markets

A brief review of HWP accounting model assumptions made for key export markets was undertaken. Australia and the USA have been important markets for sawn timber exports. Both countries have developed Tier 3 HWP modelling systems which separate products by cohorts according to age, and assign different discard rates to each. Jaakko Poyry Consulting (1999) divide HWPs into five pools based on life spans in use. The long term products with a life span of 90 years include softwood framing and mouldings, which include both domestically-produced and imported radiata pine.

Half lives used in the United States greenhouse gas inventory are given in Table 9. Recent work suggests that the IPCC default half life and first order decay function underestimate carbon stored in single family homes in the United States – a gamma distribution with a half live of 113 years is suggested as an improvement, based on analysis of US housing data.[10]

It is reasonable to assume that the use of wood products imported from New Zealand into Australia and the United States is similar to use in New Zealand. This assumption is harder to justify for export markets in Asia where it is known that radiata pine is heavily used in car cases, packaging and pallets, reel drums and concrete formwork. These countries have not reported HWPs in greenhouse gas inventories under the UNFCCC.

[10] http://pics.uvic.ca/sites/default/files/uploads/mcfarlane_poster.pdf

Table 9. Half lives for end uses (years) used in the United States HWP accounting model

1 family homes (pre-1980)	80
1 family homes(post-1980)	100
Multifamily homes	70
Mobile homes	20
Nonresidential construction	67
Pallets	6
Manufacturing	12
Furniture	30
Railroad ties	30
Paper (free sheet)	6
Paper (other)	1

Japan does not report HWPs in its greenhouse gas inventory.[11] Reports by Tonosaki (2004) and Nose (2005) implement the alternative approaches to accounting without providing country-specific half lives. Korea has produced a modified IPCC greenhouse gas inventory without including HWPs (Dowon et al 2010) and an implementation of the default IPCC approach to HWP accounting (Yun and Cha 2008). Cha et al (2011) reported that the life-span of Korean domestically produced wood is shorter than for imported wood, which is mostly used for long lived wood products such as lumber in wooden house. In contrast about sixty percent of domestic wood is used for pulp production and medium density fiberboard production. The service life of a Korean house was assumed to be 50 years. Tsunetsugu and Tonosaki (2010) reported an even shorter average life span of only 35 years for wooden buildings in Japan. A forest carbon budget for China has been published (Lun et al 2012) which included HWP life span assumptions from Bai (2010). Rather than providing half lives for the eleven market segments identified, Bai (2010) assigns probabilities that each of 12 life span limits will be reached. Even if national half life estimates were available for these countries, they may not be appropriate for imported radiata pine.

Product and market specific half-lives for HWPs for use in Tier 3 reporting calculations can be derived from the estimated HWP service life; the likelihood of obsolescence and the market share of the different HWP categories (see Equation 7).

Equation 7: **HWP Half-life = ((ESL*O)*MA))*ln$^{(2)}$**

where:
O = obsolescence factor (0-1 scale)
ESL = estimated service life (years),
MA = the Market share adjustment (%)

[11] Japan has used a Tier 3 HWP modelling approach for building products in constructing a Forest Management Reference Level, with half lives of 20 years for other products and 2 years for paper.

This approach was used to derive an initial estimate for New Zealand's markets. The HWPs were split into Construction, Temporary construction, Furniture, Packaging, and Paper sub-product categories. Specific details for the calculation of the estimated service life are from ISO15686-8:2008, which states that the obsolescence factor should be based on "*designer's and clients experiences, and if possible, documented feedback from practice*". The estimated service life and assumed obsolesce factors used in this study are detailed in Table 10.

Table 10: Assumptions and data used to calculate half-life equations.

Sub-Product	Estimated service life (years)	Obsolescence factor[3]
Construction	80[1]	0.9
Furniture	20[2]	0.6
Packaging	10[2]	0.3
Paper	2.5[2]	0.1

[1]Informed by (Athena, 2008; Love & Szalay, 2007; Nebel & Drysdale, 2009; Puettmann et al., 2010b; Sandilands et al., 2008; Skog & Nicholson, 2000).
[2]From (Hashimoto & Moriguchi, 2004).
[3]Assumptions based on personal estimate of potential obsolescence of each sub-product category using life cycle inventory data from (Frischknecht et al., 2005; Hubbard & Bowe, 2010; Puettmann et al., 2010a; Puettmann et al., 2010b).

The sub-product market shares were estimated using published data on market shares (Chunquan et al. 2004; Hashimoto & Moriguchi 2004; Kun et al. 2007; MEF 2009; Phillips & Choi 2006), discussions with processors (CHH), exporters (TPT, PFP), consultants and researchers (Indufor, Forest trends, UBC) and inference from macro-economic and material flow assessments (Frischknecht et al. 2005; Michinaka et al. 2011).

These were used to produce the market specific half-lives that are summarised in Table 10.

Table 11:Calculated country specific half-lives for exports.

	Sawn-wood	Panels	Paper and Paperboard
Japan	4.6	6.0	1.1
Korea	7.0	12.2	1.1
India	6.9	20.1	0.9
China	6.6	35.8	1.7

Compared to the default values (35 years sawn wood; 25 years panels; 2 years paper) the calculated half-lives for radiata sawn timber are much lower. This is because New Zealand radiata pine is assumed to be used in export markets for short-lived products such as temporary construction, pallets and packaging (Katz 2004; Katz 2005). Conversely, the panel product half life estimated for China was greater than the IPCC default. This is because of the relative proportion of panel products that are assumed to go into the construction sector as opposed to non-structural use such as packaging.

The method to calculate product half-lives involves numerous simplifications and due to data accessibility and quality issues there is a significant amount of conjecture and guesswork. The service life, obsolescence factor and market shares are likely to vary between species and over time; indeed some of the sources (e.g. Hashimoto & Moriguchi, 2004; Kun et al., 2007) provide varying product breakdowns over several decades. Hashimoto and Moriguchi (2004) stated that the allocation of imported sawn timber and plywood to market segments was unknown, so proportions used for domestic production were used.

Consequently the variability associated with these half-lives is likely to be considerable. Donlan et al. (2012) estimate an uncertainty level of +/- 30%, but our calculated half-lives differ from the IPCC estimates by considerably more for sawn timber and paper products. Using a Tier 3 methodology for half-lives would probably reduce the contribution to removals made by HWPs during the second commitment period unless there was a strong shift of radiata pine into longer-lived market segments. Note that as described previously, the life span of wooden houses assumed in Japan and Korea is much shorter than in Australia or the United States. More detailed in-country investigation of exported HWP use and material flow within importing countries is needed to validate some of our assumptions.

MODEL RESULTS

An Excel spreadsheet was constructed to take estimates of roundwood and HWP production, imports and exports since 1900, convert them to tonnes of carbon, exclude the share derived from imports, and model changes in the pool over time. The model also provides estimates of the proportion by forest sub-category and activity from LUCAS emissions estiamtes.

Allocation of carbon to the three HWP pools

Figure 11 shows the allocation to the three semi-finished HWP categories from 1990 for a scenario in which IPCC default IPCC parameters are used. Only HWPs produced in New Zealand are included, whether the product is consumed domestically or exported) and the estimates have been scaled down to allow for a contribution from imported fibre, according to the default approach. In 2011 29% of the harvest was allocated to products. When New Zealand-specific parameters are used (including an annual weighted mean wood density) the total allocation to products is slightly higher (dashed line in Figure 11).

Allocation to HWPs from a scenario that included HWPs produced from exported logs is shown in Figure 12. The total allocation is over 60% in 2011 (total allocation from the model that excluded exported logs is shown for comparison).

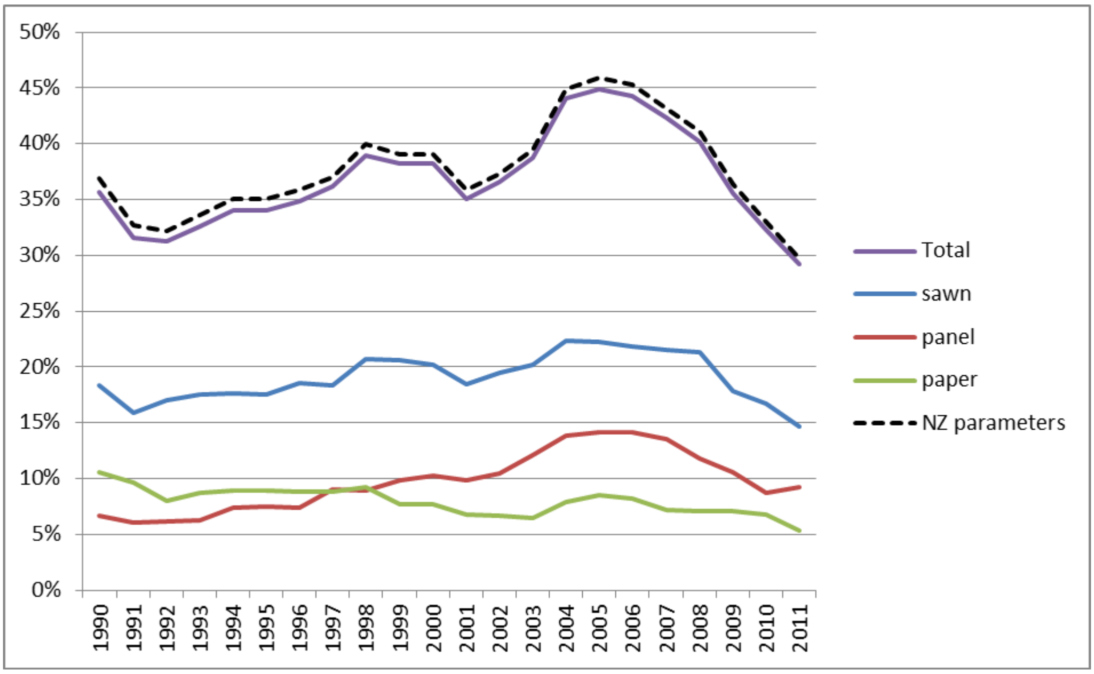

Figure 11. Allocation of harvest to domestically produced HWPs: IPCC scenario

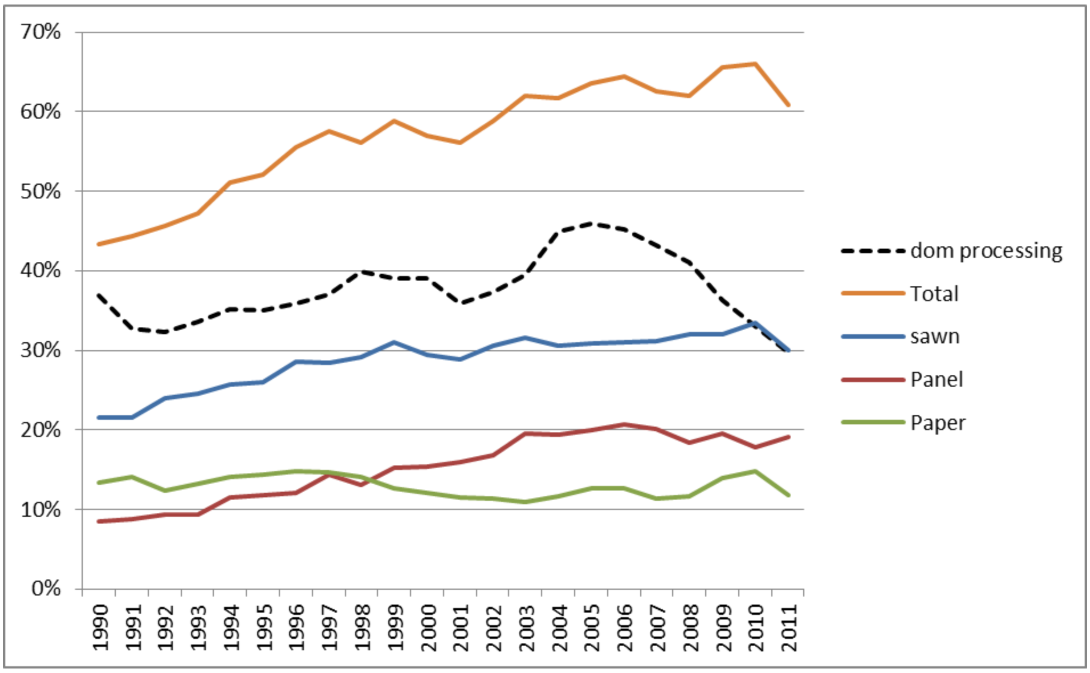

Figure 12. Allocation of harvest to HWPs including export log conversion. "Total" includes HWPs produced in NZ and overseas; "dom processing" is the total produced in New Zealand, regardless of where they are consumed.

Manley and Maclaren (2010) estimated that in 2009, 21.1 per cent of the harvest wood fibre ended up in products for domestic consumption, with the remainder being exported or waste. If exported HWPs were included and exported logs assumed to be converted into products in the same proportion as domestically, 78.4% was captured in HWPs. This is higher than in Figure 12, which excluded carbon in poles and exported chips and pulp.

Under a scenario domestic processing remains at a constant level while log exports take up the projected increase in harvesting, the total amount allocated falls to 19% by 2020 if exported raw materials are accounted for as an instantaneous emission at the time of harvest.

Carbon stocks in HWP pools are shown in Figure 13 for the scenario that uses default IPCC backfilling, carbon conversion factors and half lives. Conversion of export logs is assumed at the domestic processing proportions and paper produced from export chips and pulp is included.

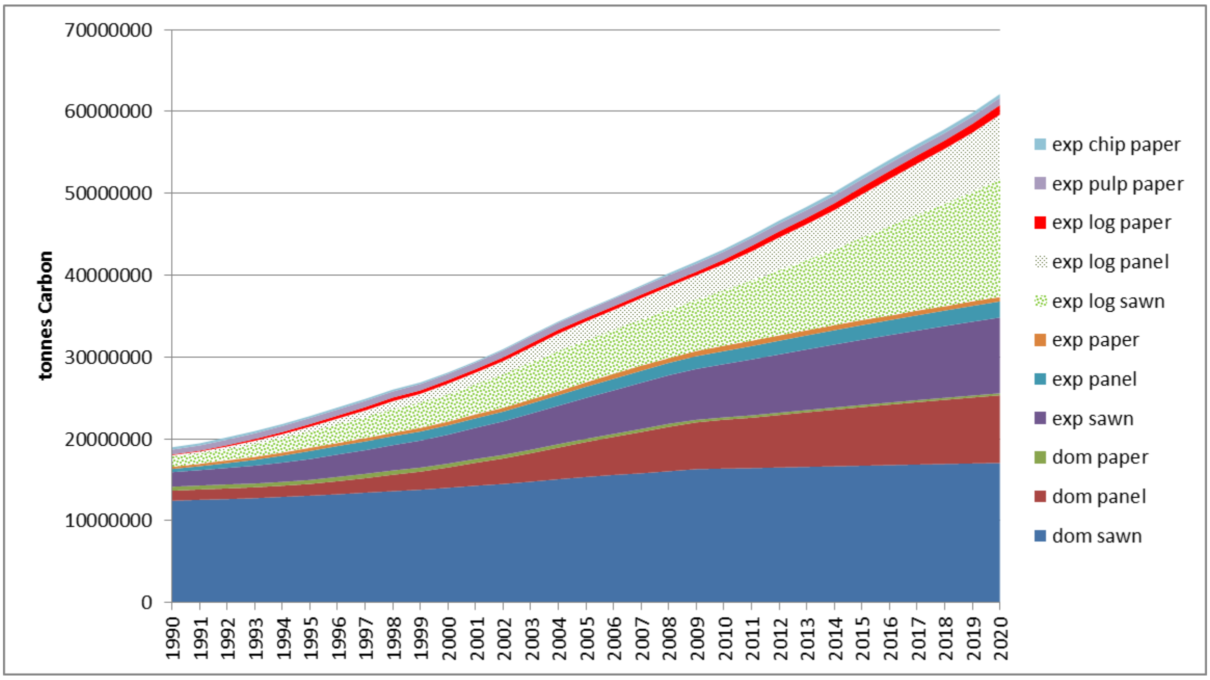

Figure 13. Carbon stock in HWP pools: default parameters

Figure 14 shows the result based on NZ parameters and country-specific half lives for export markets. Results are very similar – HWPs used domestically assume the same half life as does all paper. Stock build up is lower in sawn wood and panels due to the generally shorter half lives (Figure 15 and Figure 16).

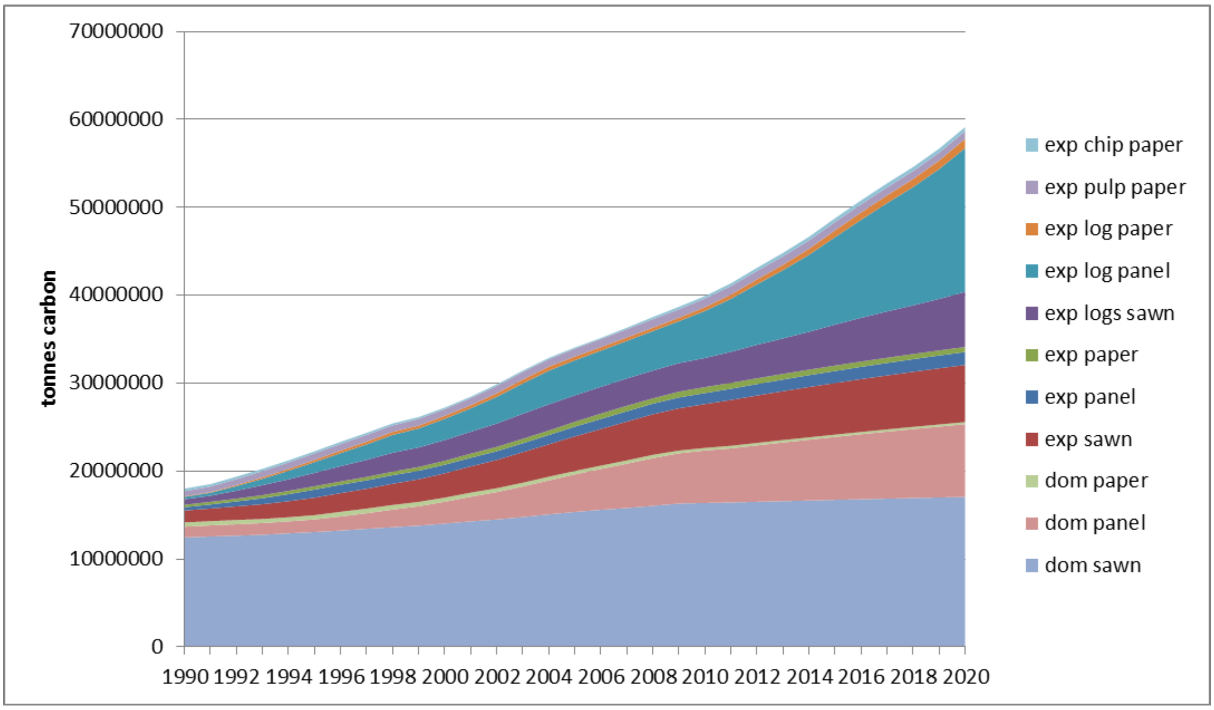

Figure 14. Carbon stock in HWP pools: country-specific half lives

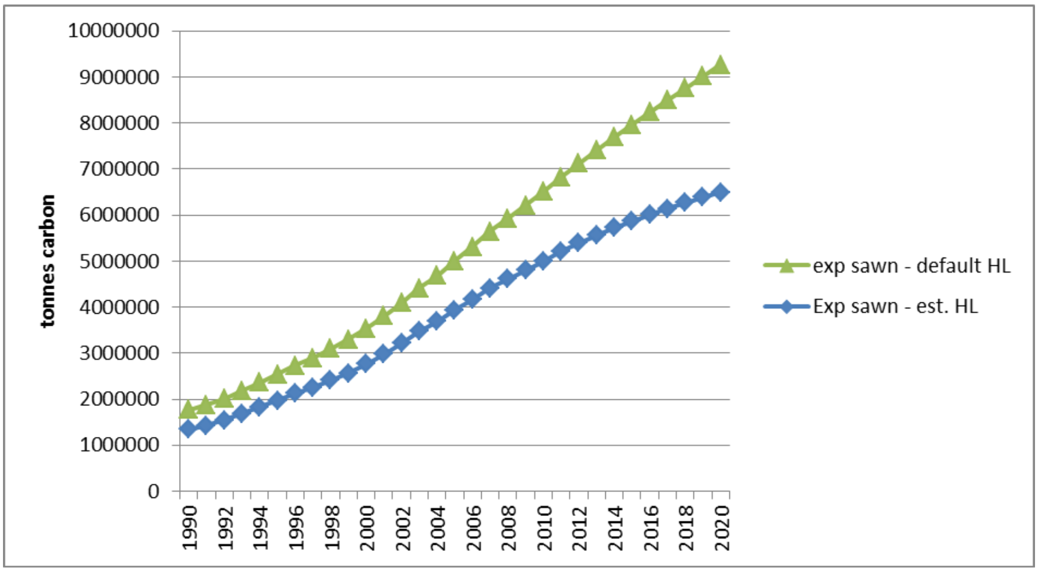

Figure 15. Exported sawn wood stocks using default and estimated country-specific half lives.

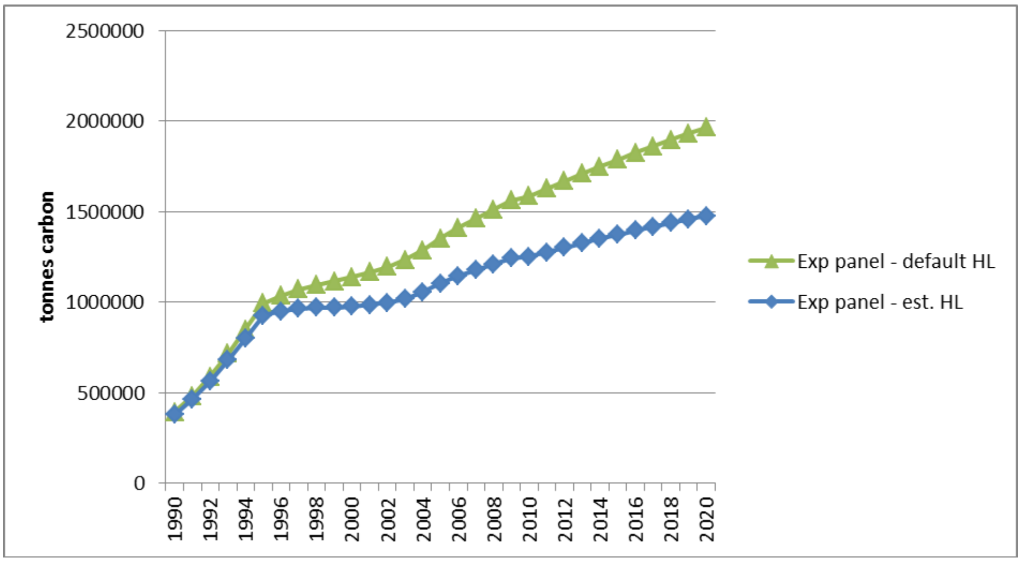

Figure 16. Exported panel stocks using default and estimated country-specific half lives.

KYOTO PROTOCOL ACCOUNTING

For Kyoto Protocol accounting, only the change in HWP stocks since 2012 enter the pool to be accounted. Stock changes in the pool of HWPs produced between 2013 and 2020 will depend on:

- Harvest and deforestation rates
- Product mix produced in New Zealand
- Half lives assumed for products produced in New Zealand, both locally and overseas.
- Whether exported raw materials are allowed to contribute, in which case assumptions on conversions rates, market segments and half lives are key.

Figure 17 shows the annual stock change in the HWP pool from post-2012 harvesting only, under a scenario in which domestic processing remains at 2012 levels while the harvest increases, leading to an increase in log exporting. The combined pool of HWP's produced in New Zealand (DOM HWP and EXP HWP) decreases as the inputs from constant processing are less than the assumed outputs from discards. The same applies to paper made from exported pulp and chips, while the pool of HWPs made from exported logs (EXP log) increases. This scenario assumed that export logs would be converted to HWPs in the same proportions as for domestic processing, with the same half lives applied. The contribution from the production of poles is also indicated.

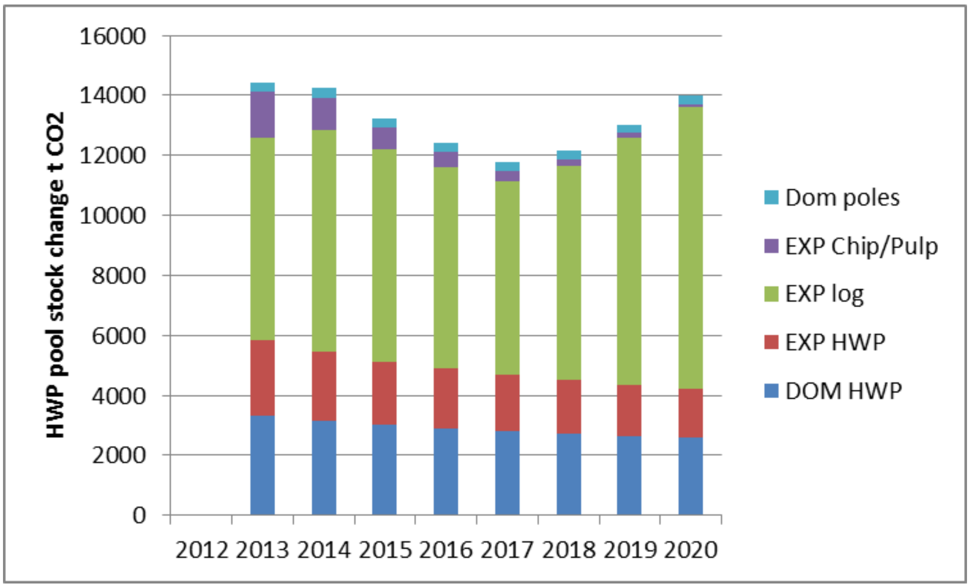

Figure 17. Stock change in HWP pools.

If only HWPs captured within FAO data can be included, the average annual stock change over the CP is 4886 Gg CO_2 per year. This is only 38% of the average total stock change (12859 Gg CO_2 per year) when HWPs produced from exported raw materials are also included.

According to LUCAS data, in 2011 96% of the combined harvest and deforestation emissions were from pre-1990 forest harvesting. These emissions will be accounted for against the FMRL. For this component the details of the scenario are largely irrelevant – regardless of assumptions made on the exclusion of exported raw materials, half lives or carbon content of HWPs, the impact on accounts will be neutral as long as the same assumptions are made in both the FMRL and CP2 reporting.

There remains the possibility that actual net removals will be higher than those in the FMRL if, for example:

- the rate of harvesting and deforestation is lower than in the FMRL;
- a greater proportion of logs is processed domestically (assuming exported raw materials are excluded from accounting);
- a greater proportion of logs is converted to HWPs with longer life spans;
- a greater proportion of exported logs is sent to markets with longer life spans and/or higher log-to-product conversion rates.

IPCC guidance would have to be followed to determine which if any of these factors triggers a technical correction to the FMRL, and therefore a neutral outcome. Draft guidance suggests that the FMRL can assume a constant mix of products produced, based on the average of the mix in 2008-2012. It will be easy to show that the actual product mix produced in New Zealand has changed, based on FAO data. Proving changes in the processing and end use of exported logs will be very difficult without data from those countries. It would also be difficult to show any change in life spans for domestically processed HWPs without a much better understanding of the baseline situation.

Since HWPs arising from deforestation are counted as instantaneous emissions, the accounting contribution from deforestation is zero regardless of assumptions made on such factors as wood density, half lives and markets. In 2011 about 3.5% of the combined harvest and deforestation emissions were estimated to be from deforestation, based on LUCAS estimates of above-ground biomass loss by activity (Table 12). Projections for the 2013-2020 period were not available from LUCAS, but the latest deforestation survey (Manley 2013)[12] suggests that deforestation will increase during the second commitment period compared with the assumption made in the FMRL modelling. This difference represents an accounting loss to New Zealand that can be estimated.

The proportions of area felled by activity assumed in the FMRL are given in Table 12.[13] If these proportions were maintained during CP2, then only the 11.4% contribution from post-1989 forest harvesting would contribute towards HWP accounting. The Manley (2013) deforestation survey does not separate pre-1990 and post-1989 deforestation, but indicates that 85% of total deforestation by large owners from 2008-2020 would be pre-1990 forest, while small owners were assumed to deforest 80% of their harvested stands. Total deforestation of 55,000 ha from 2013-2020 was projected. It was assumed that 85% of this deforestation would be in pre-1990 forest, with 15% in post-1989 forest.

Table 12. Contribution to roundwood removals by activity

	LUCAS 2011 year (% of AGB losses)	FMRL 2013-2020 (% of area)	2013-2020 with increased deforestation (% of area)
Pre-1990 forest harvesting	96.2	84.7	77.6
Pre-1990 forest deforestation	2.5	3.7	10.8
Post-1989 forest harvesting	0.3	11.4	9.8
Post-1989 forest deforestation	1.0	0.2	1.8

If actual deforestation increases as indicated by Manley (2013), then pre-1990 harvesting would drop to about 78% of the total and pre-1990 forest deforestation would increase to 11%. In other words, if it is assumed that the total area felled remains the same as in the FMRL while the proportion deforested increases, then about 7% of the carbon transferred to the HWP pool in the FMRL would instead be instantly emitted. The contribution of this component has been quantified in Table 13 under three half life assumptions.

Table 13. Annual stock change in HWPs over CP2 (Gg CO_2 year^{-1}) based on 7% of total.

Half lives	Domestic processing only	HWPS from exported raw materials + poles	Total
Long: 70/50/4	377	656	1033
Default: 35/25/2	347	588	935
Short: 17.5/12.5/1	309	512	820

[12] Manley, B.R. 2013 Deforestation Survey 2012. MPI Technical Paper No: 2013/02, NZ School of Forestry University of Canterbury

[13] Calculated as a percentage of total area felled. This slightly over-estimates the contribution from post-1989 forests relative to pre-1990 forests, because younger post-1989 stands with lower average biomass are harvested and deforested before 2018.

New Zealand's FMRL (excluding the HWP pool contribution) is an annual emission of 11 150 Gg CO_2 for the 2013-2020 period. The values shown in Table 13 are net removals (the pool of HWPs produced since 1 January 2013 HWP is growing) and represent the amount that would have been captured in the corrected FMRL under business as usual management but will instead be accounted for as an instantaneous emission because of increased deforestation. This lost opportunity is about 3% annually (2.8-3.4% for the half-life variations modelled) if only the semi-finished products captured by FAO data are accounted for, rising to 7-9% if posts and poles and HWPs produced from exported roundwood are also included. These estimates assumed that exported logs would be converted to HWPs in the same proportions as for logs processed domestically, with the same half-lives applying.

In summary, under FMRL accounting only a difference between the HWP pool change assumed in the (revised) FMRL and the actual HWP pool change is of consequence. The impact of this difference is minimised under assumptions that minimise the contribution of HWPs, such as very short half-lives and no contribution from exported raw materials.

In contrast, stock changes in HWPs from harvested post-1989 forest are all accounted for. The FMRL assumed that by 2020 a third of the harvest would be from post-1989 forest, but the contribution to CP2 as a whole is smaller as little harvesting from post-1989 forest takes place earlier in the period. If the Manley (2013) deforestation projections are assumed, about 11.4% of roundwood production would be from post-1989 forest (Table 12). This would equate to about 557 Gg CO_2 per year for domestically processed logs or 1501 Gg CO_2 per year including HWPs from exported raw materials and poles.

In all cases these estimates are based on converting FAO production and trade data to carbon. It should be noted that the while the FMRL value implicitly includes an estimate of the carbon instantly emitted due to harvesting, this estimate is not derived in the same way as the estimates in Table 13. The FMRL was derived from modelled harvest and deforestation emissions using a national carbon yield table based on NEFD volume yield tables converted to carbon. Estimates need to be scaled to ensure consistency between the FMRL and reporting. Without scaling, the impact of increased deforestation would depend on the basic density assumption as shown in Table 14. All results are for the IPCC default half lives, but the IPCC default basic density for softwoods is higher than the published estimate for radiata pine (420 kg/m^3). A low estimate based on LUCAS plot data is also provided as an alternative scenario. However, the FMRL value should also change if the basic density assumed is changed.

Table 14. Annual stock change in HWPs over CP2 (Gg CO_2 $year^{-1}$) based on 7% of total.

Softwood basic density (kg/m^3)	Domestic processing only	HWPS from exported raw materials + poles	Total
IPCC default: 450	347	588	935
NZ base: 420	327	530	857
NZ low: 380	306	495	801

Discussion

UNFCCC reporting versus Kyoto Protocol reporting
The data compiled for this report serves two reporting purposes – annual greenhouse gas inventory reporting under the UNFCCC and reporting for the Kyoto Protocol second commitment period. The reporting requirements differ substantially and have different implications. HWPs contribute towards a binding target under Kyoto Protocol accounting, whereas HWP reporting is currently still optional under the UNFCCC. However since New Zealand has not signed up to a legally binding commitment in the second commitment period this distinction is no longer critical. New Zealand still intends to report emissions and removals under Kyoto Protocol reporting rules.

There are several other differences in reporting requirements. Firstly, UNFCC reporting requires estimates of carbon stocks and stock changes in the HWP pool since 1990 (including emissions from HWPs produced earlier). This means that production data is required from 1900 to initialise the HWP pool as at 1990. In contrast, HWP production data from 1900 to 2012 is irrelevant to Kyoto Protocol reporting because inherited emissions do not need to be captured.[14] Secondly, UNFCCC reporting is based on two default products (solid wood and paper) with no agreed accounting approach. Instead, variables are calculated that can be used in all four proposed approaches. KP reporting uses three products and a single agreed accounting approach. The KP accounting approach is similar to the UNFCCC *production approach* to HWP accounting, but with an important difference. Whereas the default UNFCCC reporting methodology assumes that exported logs will be converted to products in the same proportions as in domestic log conversion, the Kyoto Protocol guidance does not allow this assumption to be made. Instead "transparent and verifiable" data on HWP production from export logs is required. In the absence of these data, carbon in exported logs must be instantly emitted at the time of harvest.

It seems likely that UNFCCC reporting of HWPs will become mandatory in future, using an approach that is consistent with the Kyoto Protocol reporting approach. Until then New Zealand still has the option of either reporting the set of HWP variables in the annual greenhouse gas inventory or not reporting any HWP information. The *atmospheric flow* approach remains the most favourable of the four approaches for New Zealand, because credit is obtained for all carbon grown in logs but debits are incurred only for logs consumed within New Zealand. The KP accounting approach fits between the *stock change and production approaches*, since unlike in the stock change approach there would be no liability for emissions from imported HWPs, but unlike *the production approach* the emissions from exported logs would not be delayed.

While there are no fiscal consequences from applying HWP accounting, the data compiled still provides a basis for reporting and informing policy development related to future carbon reporting and accounting regimes. It could also contribute to domestic policy development, such as the potential inclusion of HWPs in the Emissions Trading Scheme. This has not been considered in this report, although there are clearly implications from the fact that half of the annual harvest is exported without processing, and exported HWPs may be applied in ways that have very different half-lives to their domestically-consumed counter-parts.

[14] For post-1989 forest, anything harvested between 2008 and 2012 has already been accounted for as an instantaneous emission, and the small amount of harvesting before this is insignificant.

HWP accounting model

The HWP accounting model developed for this report is similar in concept to the IPCC model created for UNFCCC reporting. It is based on the rule that only allows semi-finished products to enter the accounting system and the fact that production of these products is known from FAO data. Roundwood production is also required so that HWPs derived from imported raw materials can be determined and excluded.

The model is not a material balance mass flow model - it does not trace harvested fibre through the processing chain. This means it does not identify residue flows to all possible products or quantify fibre burnt for energy, used for other purposes (for example animal bedding, composting) or landfilled. It is theoretically possible for the sum of carbon in products to exceed the carbon in harvested roundwood, because no account is made of stockpiling between years and the estimates of roundwood and HWP production are treated as independent variables, rather than linked through allocation routines. In practice this is unlikely, because the FAO annual roundwood production estimates are based in part on back-calculations from product out-turn.

By including roundwood production, it is possible to estimate the proportion of harvested roundwood allocated to each HWP. This means that the HWP pool estimates can be calibrated with forest model estimates of stem carbon emitted through harvesting and deforestation. This does not appear to be a requirement of the default Kyoto Protocol accounting approach, which simply requires the HWP pool estimates to be attributed to forest sub-categories and activities. However it does create a closer link between the forest model and HWP pools. Further work is required to investigate the discrepancy between above-ground biomass losses due to harvesting and deforestation in the forest model, and roundwood removals estimated from FAO data.

The IPCC recommended approach for HWP accounting is to maintain individual products where possible, to separate domestically consumed products from exported products and to apply half-lives used by the importing country. When combined with the forest sub-categories and activities this creates 1078 carbon pools to track:

- Sixteen HWPs (two sawn wood, six panels, eight paper and paperboard).
- Up to 11 countries (8 for sawn wood, 11 for panel and 9 for paper importers - enough to capture 80% of exports for each plus an “other countries” category and the domestic market.)
- Seven combinations of land category and activity (pre-1990 natural forest and planted forest, post-1989 forest with harvesting and deforestation for each, as well as harvesting of non-forest.

Excluding the HWPs modelled as instantaneous emissions still leaves 462 pools. If products converted from exported raw materials are included they need to be kept separate. Log and pulp exports would each require five export markets with two for chip exports. This would add another 240 pools to track, excluding products accounted for as an instantaneous emission. Ideally this would be expanded further. For example plywood may be used in joinery, furniture, and temporary construction; each with different half-lives. The model would be improved by allocating semi-finished HWPs to these market segments.

The model developed for this report is greatly simplified compared with this theoretical ideal. All paper and paperboard products are aggregated before conversion to carbon and the default half-life for paper is retained in all markets (effectively treating the world as a single market). Panels are aggregated after conversion to carbon, as is sawn wood. In both cases a weighted half-life is applied in the major markets (the key export log markets - Japan, Korea, China and India - plus Australia, the USA, South-east Asia and Others). This resulted in three carbon pools for HWPs produced and consumed in New Zealand, 17 pools for HWPs produced in New Zealand but exported, 11 pools for HWPs produced from exported logs and two for paper produced from exported pulp and chips – a total of 33 pools which must then be allocated to the three activities.

A more complete model could be developed, or models developed and used for HWP reporting by countries such as Australia and the USA could be adapted. This could include alternatives to the first order decay approach. In all cases, countries accounting for HWPs are encouraged to verify HWP stock estimates made using flux methods (such as the first order decay function) with inventory methods. Approaches to verifying stock estimates have not been considered in this report but are an important part of on-going reporting.

The model has been developed to align with rules agreed in Durban (Decision 2/CMP.7), and IPCC guidance on good practice in reporting for accounting under the Kyoto Protocol. Drafting of the guidance is still under way at the time of this report, and has to be formally adopted. Interpretations may change and restrictions may be eased or tightened. Restrictions on the inclusion of poles, sleepers and chips are probably designed to minimise the potential for double-counting. Under a Tier 3 approach New Zealand could include these products provided it is possible to demonstrate that double-counting has been avoided. Including assumed production of HWPs from exported logs without good data appears to be unacceptable. Major changes are possible for any future commitment periods, in which case a full material balance model that includes fuelwood, waste flows and landfills may be required. There is limited flexibility within the current model to adapt to some changes provided data is available.

Exclusion of HWPs sourced from some activities
The exclusion of some HWPs on the basis of their origin is mainly to ensure accounting integrity. This is the case for HWPs originating from lands for which carbon stock changes have not been accounted, such as cropland and grassland. If stock changes due to harvesting were accounted for under Cropland Management or Grassland Management there would no longer be a need to exclude the resulting HWPs from the model. The exclusion of HWPs derived from imported materials is made on the same basis – the party that accounts for the gain due to inflow into the HWP pool should be the party that accounted for the loss in the forest pool. In the case of exported raw materials, the forest-growing country incurs the loss at harvest but neither country accounts for the gain in the HWP pool when products are produced, according to the draft guidance. At a global level there would be no loss of integrity in allowing one party or the other to account for the HWPs produced – the difficulty is in obtaining data. The exclusion of HWPs resulting from deforestation is probably intended to further discourage the activity – otherwise the stock changes would simply be accounted for as they occur.

Compliance with reporting requirements
The model as developed allows New Zealand to report at Tier 3 under the Kyoto Protocol, where Tier 2 uses the IPCC default method and parameters and Tier 3 can be achieved simply by adopting New Zealand-specific parameters in some cases. However, the data compiled is not sufficient for HWPs derived from exported raw materials to be included in accounting, so these must be treated as instant emissions unless the guidance can be made

less restrictive. There is no such issue with UNFCCC reporting, as the methodology allows export logs to be allocated to HWPs using domestic processing proportions. In general, progression to a higher tier is encouraged and will be required if HWPs are a key category. A higher Tier could include national rather than FAO data, with a clear description of how they differ. It is possible that New Zealand could then use national data for "sawn timber" that included posts, poles and sleepers – products that are excluded from accounting under the FAO definition. Whether this is acceptable to reviewers will depend on the final guidance.

Under FMRL accounting (pre-1990 forests), whether or not export logs are included in accounting has little significance. If the harvest level and the treatment of HWPs is the same during CP2 as assumed in the FMRL, then no credits or debits will accrue. The exclusion of exported raw materials does rule out the possibility of gaining credits through a change in markets (e.g. a switch to a market that assumes a greater proportion of sawn wood with a longer life span). It would be difficult to justify such a claim based on the data available. The export log issue is of greater importance for post-1989 forest harvesting as all emissions and removals enter accounting. Harvesting of post-1989 forests is expected to be at a low level until the last few years of CP2, but will be of increasing importance after 2020.

Improvements to the model

Data and assumptions used in the model are very broad and there is room for improvement. Potential gains from fine-tuning the model have to be weighed against the additional costs and the potential for more accurate reporting to have an adverse effect on the contribution of HWPs to accounts. Examples of improvement include:

- FAO data contains many errors and discrepancies between sources (such as imports and exports between parties in the bilateral trade data). Posts and poles (other industrial roundwood) needs to be kept separate in production data.
- Some product disaggregation would be in New Zealand's favour, such as treating LVL as a separate product with a longer life span.
- Sampling to obtain a statistically valid estimate of the mean wood density of harvested roundwood would be an improvement over using a text book value for such a variable parameter. More detailed information on the range of panel products produced annually would allow more accurate conversion of product quantities to carbon, particularly for fibreboard.

Most of the carbon removed from the forest at the time of harvest in New Zealand is subsequently exported. The fate of carbon in our export markets is the most important issue to be addressed. This goes beyond carbon accounting – if New Zealand is to maximise the value from its forests then exporting unprocessed logs to be used for unknown but probably low-value end uses cannot continue at such high levels. There is a need for hard data on the use of HWPs exported from New Zealand within the importing country, and for the conversion of exported logs and their ultimate market segment of HWPs produced from them. There is no data that meets draft good practice guidance standards for the half of the annual harvest that is exported in log form. Applying international or national mill conversion factors and residue recovery rates will not be accurate if raw materials from New Zealand are not a large component of log supply. Conversion rates vary over time due to technological advances, changing markets, changing priorities for residues, and resource differences. Mills processing radiata pine vary from small, out-dated inefficient operations to large integrated modern plants.

The other key driver for New Zealand's HWP accounts are the half-lives assumed. There are several difficulties here:

- Lack of research on HWP half lives within New Zealand.
- Wide range of end uses of radiata pine with a wide range of life spans, even within the same semi-finished product category.
- Radiata is not the dominant species used in importing countries and its use may not be typical of other species.
- Products produced in NZ are not necessarily used in the same way as products produced locally from logs imported from New Zealand.
- Little empirical evidence of allocation of HWP to market segments, leading to a reliance on often contradictory opinions.

The default half-lives for sawn wood and panels may be suitable for radiata pine products used in New Zealand, Australia and the USA, but are highly likely to be over-estimates for radiata pine used in other export markets. Nevertheless, IPCC guidance suggests that using the same half-lives as assumed by the importing country is acceptable, which is likely to be in New Zealand's favour.

Conclusions

- The FAO production and trade data compiled for this report can be used to meet the requirements for UNFCCC reporting of HWPs, but more work is needed to calculate the specific reporting variables required. Alternatively, New Zealand can continue to elect not to report HWP information under the UNFCCC, as it is still optional.
- The data required for KP reporting in CP2 is not yet available, as only production and trade data from 2013-2020 are used for this. The data compiled can be used to estimate the HWP contribution in the FMRL by applying the projected proportional allocation to products to the harvest within the FMRL. Data obtained during CP2 from the same FAO source would then meet KP reporting requirements, assuming it continues to be collected. However FAO data are not sufficient to include HWPs derived from exported raw materials within this allocation. There is no available data on the conversion of export raw materials that meets the standards required by draft IPCC guidance.
- Under FMRL accounting (pre-1990 forests), whether or not export logs are included in accounting may not be significant – as long as the same assumption is made in both the FMRL and reporting there will be no net debits. The lack of data does remove the opportunity to gain credits through changing the allocation of export logs to markets. The issue is of greater importance for post-1989 forest harvesting, which will be of increasing importance after CP2.
- To overcome the lack of transparent and verifiable data on HWPs derived from exported raw materials, New Zealand has three options: negotiate broader rules that allow conversion assumptions to be applied to raw material exports; collect appropriate data in major export markets, or minimise the issue by increasing the proportion of domestic processing. A cost-benefit analysis of these options is beyond the scope of this report. The benefit in capturing more HWPs within the accounting system will be driven largely by the carbon price and discount rate, since the first order decay approach assumes that the carbon in HWPs in-use will

all ultimately be released. Given that half of all logs harvested are exported, the inclusion of HWPs derived from exported logs would be expected to double the contribution of HWPs to New Zealand's net position. However the benefit would be reduced if life spans of HWPs in export markets are lower than in New Zealand.

- In the short-term IPCC default half-lives could be used for HWPS consumed in NZ, with country-specific half-lives used in export markets. New Zealand would be expected to improve on those assumptions over time, in which case more work is needed to establish defensible half-lives both within New Zealand and overseas.
- Parties are encouraged to verify estimates made using flux approaches (such as the first order decay approach) with estimates based on inventory approaches. Thus while FAO data is considered to be sufficient for reporting, alternative approaches may need to be investigated.

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Appendix I – UNFCCC and Kyoto Protocol Reporting

UNFCCC REPORTING

Under the United Nations Framework Convention on Climate Change (UNFCCC), Parties have a commitment to calculate and report on their national carbon budget, as part of their national Greenhouse Gas (GHG) inventory. Calculations and reporting of greenhouse gas emissions by sources and removals by sinks must be consistent with IPCC guidelines. Inventory reporting guidelines were originally published in 1995 and updated as the "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories " (*1996-Guidelines*, IPCC, 1997).

These guidelines were further elaborated by the 2000-GPG: "Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories" (IPCC, 2000a) and 2003-GPG: "Good Practice Guidance for Land-Use, Land-Use Change and Forestry" (IPCC, 2003). Whereas the 1996-Guidelines provided methods for only a few selected activities and above-ground biomass, GPG-LULUCF provided expanded guidance covering a defined set of pools (above-ground, below-ground, deadwood, litter and soil carbon), and provided for comprehensive land-based rather than process-based accounting. Classification of land now occurs based around six uses: Forest land, Grassland, Cropland, Settlements, Wetlands and Other Land. Finally an attempt was made to rationalise the 1996-Guidelines, 2000-GPG and GPG-LULUCF into a single set of inventory guidelines: the "2006 IPCC Guidelines for National Greenhouse Gas Inventories" (2006-Guidelines; IPCC, 2006). This included the amalgamation of the Agriculture and LULUCF sectors as AFOLU (Agriculture, Forestry and Other Land Uses).

The 2006-Guidelines are expected to be accepted for use in national inventory reporting from 2015[15]. They follow the same basic methodological approaches as the 1996-Guidelines and GPG-LULUCF. The Agriculture and LULUCF sectors are integrated within the new AFOLU sector (Agriculture, Forestry and Other Land-Uses) which retains the basic structure, methods and definitions used in GPG-LULUCF. Chapter 12 provides guidance and methods for estimating carbon stock changes in HWPs under alternative accounting approaches. The *Production, Stock Change* and *Atmospheric Flow* approaches were developed at a climate change workshop in Dakar, while the *Simple Decay* approach was suggested by New Zealand at a later date. The approaches differ in their treatment of where and when emissions occur. In all but the Simple Decay approach, logs removed from the forest result in an emission from the forest pool, with a simultaneous gain in the semi-finished HWP pools. Residues that are not included within one of these products (e.g. burnt as fuel or composted) are assumed to be instantly emitted at the time of harvest. In all cases, a default assumption is made that conversion of export logs to HWPs is in the same proportion as conversion in the domestic market.

The introduction to the AFOLU volume confirms that the carbon stock change that is reported in national greenhouse gas inventories for land-use categories is Net Bioeme Production (NBP), which does not include harvested wood or other durable products derived from biomass (e.g., clothing). NBP is equal to gross primary production

[15] http://unfccc.int/national_reports/annex_i_ghg_inventories/reporting_requirements/items/5333.php

(photosynthesis) less plant respiration less heterotrophic respiration (decay) less carbon losses from disturbance (eg. fire and harvesting).

The guidelines also confirm that all CO_2 released from HWP is included in the AFOLU Sector – CO_2 released from wood burnt for energy is not included in the Energy Sector totals and CO_2 released from HWP in SWDs is not included in the Waste sector totals. It is suggested HWP can be reported at a national level as a separate pool (Parts 1.2.2 and 2.2.1) and subcategory (Figure 1.2), where the other sub-categories are biomass, dead organic matter and soil. It is also noted that "estimation and reporting of greenhouse gas emissions for HWP is currently a matter of policy negotiations".

The guidelines in Chapter 12:

- clarify the option of reporting "zero" as the HWP contribution.
- provide default Tier 1 methods and guidance on higher Tiers; and
- provide guidance on reporting whatever accounting approach is used.

Whereas the *1996-Guidelines* said to report HWP stock changes if stocks could be shown to be increasing, the *2006-Guidelines* state that the HWP contribution can be reported as zero if the annual change in carbon stocks is judged to be insignificant. Similarly, the change in carbon stocks in SWDs can be reported as zero if it is judged to be insignificant. This option is no longer described as the Tier 1 method.

Five HWP variables are described which can be used to calculate the HWP contribution under the different proposed approaches (Table 11). Annex 12a.1 demonstrates how to do this for the three Dakar approaches and the Simple Decay approach, although as described, the Simple Decay approach is equivalent to the Production Approach (see Wakelin *et al.*, 2008). The Tier 1 method described uses forest products data from FAO (the default activity data) which are freely and easily available to most countries. An Excel spreadsheet is provided which implements this approach, extrapolating the FAO data back to 1900 so that inherited emissions from the HWP pool can be calculated. Default half-lives are supplied. The Tier 2 method is identical, but uses country-specific values in place of the Tier 1 defaults. Tier 3 uses country-specific data and methods. This could include comparisons of HWP stocks at two points in time, tracking fluxes using detailed country-specific data and decay patterns, direct measurement of fluxes, or a combination of methods. If the HWP contribution is judged to be of a similar magnitude to key categories, then higher tier methods should be used.

In summary, under Convention reporting HWPs are reported as an instantaneous emission from the forest pools but a Tier 1 method is available for reporting variables that can be used to account for HWPs under alternative accounting approaches. Reporting of stock changes in the HWP pool is required from 1990. Estimates of production and trade are required from 1900 to the current inventory date, allowing "inherited" emissions from the pre-1990 harvest to be captured when reporting changes in the HWP pool from 1990.

Table 15. HWP variables used to estimate annual *HWP contribution* to AFOLU CO_2 emissions/removals

Variable definition	Variable names	
	HWP in “products in use”	HWP in SWDS[16]
1. Annual change in carbon stock in a) HWP in use, and b) in HWP in solid waste disposal sites in the reporting country, this is wood carbon that came from **domestic consumption** of products , **ΔCHWP $_{DC}$ = ΔCHWP IU $_{DC}$ + ΔCHWP SWDS $_{DC}$**	Variable 1A ΔCHWP IU $_{DC}$	Variable 1B ΔCHWP SWDS $_{DC}$
2. Annual change in carbon stock in a) HWP in use, and b) in HWP in solid waste disposal sites where the wood in the products came from **domestic harvest** -- trees harvested in the reporting country, this includes exported HWP to other countries, **ΔCHWP $_{DH}$ = ΔCHWP IU $_{DH}$ + ΔCHWP SWDS $_{DH}$**	Variable 2A ΔCHWP IU $_{DH}$	Variable 2B ΔCHWP SWDS $_{DH}$
3. Carbon in annual imports of HWP to the reporting country including all wood-based material - roundwood, solidwood products, paper, pulp and recovered paper	Variable 3 P_{IM}	
4. Carbon in annual exports of HWP from the reporting country including all wood-based material:- roundwood, solidwood products, paper, pulp and recovered paper	Variable 4 P_{EX}	
5. Carbon in annual harvest of roundwood for products – wood removed from harvest sites in the reporting country, including fuelwood	Variable 5 H	

KYOTO PROTOCOL ACCOUNTING AND REPORTING

Under the terms of the Kyoto Protocol of the UNFCCC, Parties agreed to take responsibility for their greenhouse gas emissions in the 2008-2012 Commitment Period (CP1). The Kyoto Protocol specifically allows for greenhouse gas removals by sinks, measured as a change in stocks, resulting from direct human-induced land use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, to count toward meeting commitments. The Durban Climate Change Conference in November 2011 agreed to extend mandatory accounting to include forest management (i.e. emissions and removals on lands that were forested before 1 January 1990). However, accounting for these emissions and removals is to be relative to a business-as-usual Forest Management Reference Level (FMRL). Only net emissions that are above the reference level will generate a debit in the carbon account.

During the first commitment period of the Kyoto Protocol (2008-2012), HWPs could not contribute towards the Kyoto target. Instead all carbon in HWPs was assumed to be instantaneously emitted at the time of harvest. However, the Durban agreement now allows for HWPs to be accounted for using a first order decay approach. The accounting approach adopted is similar to the Production approach defined for UNFCCC reporting –

[16] SWDs = Solid Waste Disposal Sites (eg. landfills)

exported HWPs may be included but HWPs produced from imported raw materials are excluded from accounting.

Accounting for Forest Management (pre-1990 planted forests) is on the basis of a comparison of actual emissions and removals with the net removals in the FMRL. Countries that want to take advantage of HWP accounting must have included the "business-as-usual" contribution from HWPs in their FMRL. Since New Zealand has not yet done this, a technical correction to the FMRL would need to be submitted, capturing the expected inflow and emissions from HWPs derived from pre-1990 planted forests. Only HWPs harvested since 2013 enter the accounting system – HWPs produced during the first commitment period were accounted for on the basis of instantaneous emission at the time of harvest, and there is no requirement to account for inherited emissions from the pre-2008 harvest where accounting is with reference to the FMRL.

Accounting for Afforestation/Reforestation (post-1989 forests) requires all HWPs produced since 1990 to enter accounting, although harvesting during CP1 will be on the basis of instantaneous emission at the time of harvest.

The UNFCCC Conference of the Parties held in 1997 in Kyoto (COP3) confirmed that the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories should be used as "methodologies for estimating anthropogenic emissions by sources and removals by sinks of greenhouse gases" in the calculation of legally-binding targets during the first commitment period. The IPCC Task Force for National Greenhouse Gas Inventories has started a process to revise guidelines to take into account the 2006 Guidelines and other IPCC products, the annex to 2/CMP.7, other relevant decisions of the COP and CMP, new scientific literature and methods, and the outcomes of a scoping meeting held in Geneva on 1 to 4 May 2012. The new guidance will be published as the *2013 Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol* (2013SG-KP).

The Durban agreement (Decision 2/CMP.7) includes a number of clauses relating to HWP accounting and reporting. In summary[17]:

- Paragraph 14 states that reporting during CP2 must be consistent with the forest management reference level, so a technical correction to the reference level is required if HWPs were not included (as is the case for New Zealand).
- Paragraph 16 states that if the reference level is based on a projection, then Parties can choose to only account for emissions from HWPs produced after the start of the commitment period (i.e. 2013).
- Paragraph 27 states that Parties must account for changes in the HWP pool, regardless of whether it is source or not.
- Paragraph 28 and 29 state that accounting for HWPs should be on the basis of the change in the HWP pool estimated using first order decay functions with half-lives of two years for paper, 25 years for panels and 35 years for sawn wood. However, if transparent and verifiable activity data is not available then accounting can be on the basis of instantaneous emissions.
- Paragraph 30 states that Parties can use a higher Tier methodology (using country-specific half-lives).
- Paragraph 31 and 33(c) state that HWPs resulting from deforestation must be accounted for as instantaneous emissions, while HWPs arising from salvage

[17] The full text of these paragraphs is included at the end of this appendix.

logging following natural disturbance must be accounted for even though other emissions due to significant natural disturbances can optionally be excluded.

Because of these accounting rules, HWPs produced in a country must be allocated to both the sub-category in which they arise (Pre-1990 Natural Forest, Pre-1990 Planted forest, Post-1989 forest, non-forest, eg. shelterbelts) and to the activity (harvesting, deforestation, natural disturbance salvage). In practice, salvage harvesting will be captured as either harvesting or deforestation, depending on whether there is a land use change. Specific estimation of salvage material will be made separately as required for natural disturbance accounting. For each combination of category and activity, the harvest needs to be allocated to domestic and local processing, and finally to the three IPCC product classes within each.

The differences between UNFCCC annual greenhouse gas inventory reporting of HWPs and reporting under the Kyoto Protocol are shown in Table 16.

Table 16. Comparison of HWP convention reporting and Kyoto accounting by forest sub-category and activity

Forest Sub-category	Activity	Processing to solid wood/panel/paper	Convention Reporting *(2006-GL)*	Protocol Accounting *(2013SG-KP)*
Natural forest (Pre-1990)	Harvest	Domestically in NZ	Included in variables 1A, 1B, 2A, 2B & H. Data from 1900 (Tier 1 uses FAO 1961 data extrapolated) NB: NF harvest not currently estimated or reported by LUCAS.	Included in Art. 3.4 accounting (within FMRL). Inherited emissions from pre-2013 harvest may be excluded if FMRL is based on a projection. Inherited emissions from CP1 harvest already accounted for as instant emission are excluded either way. Tier 2 - *good practice* to apply same half-lives to exported HWPs, but *recommended* to report them separately.
		In export market	Included in variables P_{EX} & H from 1900 – Tier 1 assumes same proportions of semi-finished products are produced NB: NF harvest not currently estimated or reported by LUCAS.	Instant oxidation unless transparent and verifiable data on semi-finished HWP production is available.
	Deforestation	Domestically in NZ	Treated as for harvest	Instant oxidation. (Exception - FLU[18] harvest treated as for harvest above).
		In export market	Treated as for harvest	Instant oxidation
	Natural disturbance (salvage)	Domestically in NZ	Treated as for harvest	As for harvest – not excluded under natural disturbance provision unless left in forest
		In export market	Treated as for harvest	as for harvest

Pre-1990 planted forest	Harvest	Domestically in NZ	All as for natural forest	All as for NF
		In export market		
	Deforestation	Domestically in NZ		
		In export market		
	Natural disturbance	Domestically in NZ		
		In export market		

[18] Flexible Land Use, or accounting under the Carbon Equivalent Forest Conversion provision.

Forest Sub-category	Activity	Processing to solid wood/panel/paper	Convention Reporting *(2006-GL)*	Protocol Accounting *(2013SG-KP)*
Post-1989 planted forest	Harvest	Domestically in NZ	Included in variables 1A, 1B, 2A, 2B & H from harvest date	Included in Art 3.3 accounting from 1900. But FLU harvest treated as for Pre-1990 PF.
		In export market	Included in variables P_{EX} & H from harvest date – Tier 1 assumes same proportions of semi-finished products are produced	Instant oxidation unless transparent and verifiable data on semi-finished HWP production is available.
	Deforestation	Domestically in NZ	Treated as for harvest	Instant oxidation. But FLU harvest treated as for Pre-1990 PF.
		In export market	Treated as for harvest	Instant oxidation. But FLU harvest treated as for Pre-1990 PF.
	Natural disturbance (salvage)	Domestically in NZ	Treated as for harvest	As for harvest – not excluded under natural disturbance provision unless left in forest
		In export market	Treated as for harvest	As for harvest

Non-forest HWPs from shelterbelts, cropland, etc	All	Both domestic and export	Included if captured by FAO data.	Instant oxidation – must be netted out HWP of production data

Imported HWP raw materials (RW, chip and veneer sheets)	Source (harvest, deforestation or natural disturbance) not distinguished	Domestically in NZ (assume no raw materials are imported and re-exported without processing)	Reported as part of variables 1A, 1B & P_{IM}	Excluded – must be netted off NZ production of semi-finished HWPs (sawn wood/panels/paper).
Imported semi-finished products (sawn wood, panels and paper)	Source (harvest, deforestation or natural disturbance) not distinguished	Domestic NZ (assume no raw materials are imported and re-exported without processing)	Reported as part of variables 1A, 1B & P_{IM}	Excluded (will not be included in NZ data for production of semi-finished HWPs).

DECISION 2/CMP.7 (DURBAN) TEXT RELEVANT TO HWP REPORTING AND ACCOUNTING

Paragraph

16. Emissions that occur during the second commitment period from harvested wood products removed from forests prior to the start of the second commitment period shall also be accounted for.
In the case the forest management reference level is based on a projection, a Party may choose not to account for the emissions from harvested wood products originating from forests prior to the start of the second commitment period, and shall ensure consistency in the treatment of the harvested wood products pool in the second commitment period in accordance with paragraph 14 above.[19] Emissions from harvested wood products already accounted for during the first commitment period on the basis of instantaneous oxidation shall be excluded. The treatment of harvested wood products in the construction of a projected forest management reference level shall be on the basis of provisions outlined in paragraph 29 below and shall not be on the basis of instantaneous oxidation.[20]

26. Each Party included in Annex I shall account for all changes in the following carbon pools: above-ground biomass, below-ground biomass, litter, dead wood, soil organic carbon and harvested wood products. With the exception of harvested wood products, a Party may choose not to account for a given pool in a commitment period, if transparent and verifiable information is provided that demonstrates that the pool is not a source.

27. Emissions from harvested wood products removed from forests which are accounted for by a Party under Article 3, paragraphs 3 and 4, shall be accounted for by that Party only. Imported harvested wood products, irrespective of their origin, shall not be accounted for by the importing Party.

28. Accounting shall be on the basis of instantaneous oxidation.

29. Notwithstanding paragraph 28 above, and provided that transparent and verifiable activity data for the harvested wood product categories specified below are available, accounting shall be on the basis of the change in the harvested wood products pool during the second and subsequent commitment periods, estimated using the first-order decay function with default half-lives of **two** years for paper, **25** years for wood panels and **35** years for sawn wood.

30. A Party may use country-specific data to replace the default half-lives specified above, or to account for such products in accordance with the definitions and estimation methodologies in the most recently adopted IPCC guidelines and any subsequent clarifications agreed by the Conference of the Parties, provided that verifiable and transparent activity data are available and that the methodologies used are at least as detailed or accurate as those prescribed above.

[19] Para 14 requires consistency between reporting and FMRL
[20] But note paragraph 32.

31. Harvested wood products resulting from deforestation shall be accounted for on the basis of instantaneous oxidation.

32. Where carbon dioxide emissions from harvested wood products in solid waste disposal sites are separately accounted for, this shall be on the basis of instantaneous oxidation. Carbon dioxide emissions from wood harvested for energy purposes shall be accounted for on the basis of instantaneous oxidation.

Appendix II – FAOSTAT Definitions[21]

FAOStat distinguishes between Transactions and Products. *Removals*, *Production*, *Imports* and *Exports* are all transactions.

Removals

The volume of all trees, living or dead, that are felled and removed from the forest, other wooded land or other felling sites. **It includes** natural losses that are recovered (i.e. harvested), removals during the year of wood felled during an earlier period, removals of non-stem wood such as stumps and branches (where these are harvested) and removal of trees killed or damaged by natural causes (i.e. natural losses), e.g. fire, windblown, insects and diseases. Please note that this includes removals from all sources within the country including public, private, and informal sources. **It excludes** bark and other non-woody biomass and any good that is not removed, e.g. stumps, branches and tree tops (where these are not harvested) and felling residues (harvesting waste). **It is reported in** cubic metres solid volume underbark (i.e. excluding bark). Where it is measured overbark (i.e. including bark), the volume has to be adjusted downwards to convert to an underbark estimate.

Production

The solid volume or weight of all production of the pre-defined products specified in the classification system. **It includes** the production of products that may immediately be consumed in the production of another product (e.g. wood pulp, which may immediately be converted into paper as part of a continuous process). Please note that this includes production from all sources within the country including public, private, and informal sources. **It excludes** the production of veneer sheets that are used for plywood production within the same country. **It is reported** in cubic metres of solid volume in the case of roundwood, sawn wood and wood based panels and metric tonnes in the case of charcoal, pulp and paper products.

Raw Material Products

Roundwood

All roundwood felled or otherwise harvested and removed. It comprises all wood obtained from removals, i.e. the quantities removed from forests and from trees outside the forest, including wood recovered from natural, felling and logging losses during the period, calendar year or forest year. **It includes** all wood removed with or without bark, including wood removed in its round form, or split, roughly squared or in other form (e.g. branches, roots, stumps and burls (where these are harvested) and wood that is roughly shaped or pointed. **It is an aggregate comprising** wood fuel, including wood for charcoal and industrial roundwood (wood in the rough). **It is reported in** cubic metres solid volume underbark (i.e. excluding bark).

[21] http://faostat.fao.org/Portals/_Faostat/documents/pdf/FAOSTAT-Forestry-def-e.pdf

Industrial roundwood (wood in the rough)

All roundwood except wood fuel. In production, it is an aggregate comprising sawlogs and veneer logs; pulpwood, round and split; and other industrial roundwood. It is reported in cubic metres solid volume underbark (i.e. excluding bark). The customs classification systems used by most countries do not allow the division of Industrial Roundwood trade statistics into the different end-use categories that have long been recognized in production statistics (i.e. sawlogs and veneer logs, pulpwood and other industrial roundwood). Thus, these components do not appear in trade. **It excludes**: telephone poles.

Pulpwood, round and split

Roundwood that will be used for the production of pulp, particleboard or fibreboard. **It includes**: roundwood (with or without bark) that will be used for these purposes in its round form or as splitwood or wood chips made directly (i.e. in the forest) from roundwood. It is reported in cubic metres solid volume underbark (i.e. excluding bark).

Chips and Particles

Wood that has been reduced to small pieces and is suitable for pulping, for particle board and/or fibreboard production, for use as a fuel, or for other purposes. **It excludes** wood chips made directly in the forest from roundwood (i.e. already counted as pulpwood, round and split). It is reported in cubic metres solid volume excluding bark.

Wood Pulp

Fibrous material prepared from pulpwood, wood chips, particles or residues by mechanical and/or chemical process for further manufacture into paper, paperboard, fibreboard or other cellulose products. It is an aggregate comprising mechanical wood pulp; semi-chemical wood pulp; chemical wood pulp; and dissolving wood pulp.

Semi-finished products

Sawnwood

Wood that has been produced from both domestic and imported roundwood, either by sawing lengthways or by a profile-chipping process and that exceeds 6 mm in thickness. **It includes** planks, beams, joists, boards, rafters, scantlings, laths, boxboards and "lumber", etc., in the following forms: unplaned, planed, end-jointed, etc. **It excludes** sleepers, wooden flooring, mouldings (sawnwood continuously shaped along any of its edges or faces, like tongued, grooved, rebated, V-jointed, beaded, moulded, rounded or the like) and sawnwood produced by resawing previously sawn pieces. It is reported in cubic metres solid volume.

Wood-based panels

This product category is an aggregate comprising veneer sheets, plywood, particle board, and fibreboard. It is reported in cubic metres solid volume.

Veneer sheets

Thin sheets of wood of uniform thickness, not exceeding 6mm, rotary cut (i.e. peeled), sliced or sawn. It includes wood used for the manufacture of laminated construction material, furniture, veneer containers, etc. Production statistics should exclude veneer sheets used for plywood production within the same country. It is reported in cubic metres solid volume.

Plywood

A panel consisting of an assembly of veneer sheets bonded together with the direction of the grain in alternate plies generally at right angles. The veneer sheets are usually placed symmetrically on both sides of a central ply or core that may itself be made from a veneer sheet or another material.

It includes veneer plywood (plywood manufactured by bonding together more than two veneer sheets, where the grain of alternate veneer sheets is crossed, generally at right angles); core plywood or blockboard (plywood with a solid core (i.e. the central layer, generally thicker than the other plies) that consists of narrow boards, blocks or strips of wood placed side by side, which may or may not be glued together); cellular board(plywood with a core of cellular construction); and composite plywood(plywood with the core or certain layers made of material other than solid wood or veneers). **It excludes** laminated construction materials (e.g. glulam), where the grain of the veneer sheets generally runs in the same direction. It is reported in cubic metres solid volume. Non-coniferous (tropical) plywood is defined as having at least one face sheet of non-coniferous (tropical) wood.

Particle Board, Oriented Strandboard (Osb) and Similar Board

A panel manufactured from small pieces of wood or other ligno-cellulosic materials (e.g. chips, flakes, splinters, strands, shreds, shives, etc.) bonded together by the use of an organic binder together with one or more of the following agents: heat, pressure, humidity, a catalyst, etc. The particle board category is an aggregate category. **It includes** oriented strand board (OSB), waferboard and flaxboard. **It excludes** wood wool and other particle boards bonded together with inorganic binders. It is reported in cubic metres solid volume.

Fibreboard

A panel manufactured from fibres of wood or other ligno-cellulosic materials with the primary bond deriving from the felting of the fibres and their inherent adhesive properties (although bonding materials and/or additives may be added in the manufacturing process). **It includes** fibreboard panels that are flat-pressed and moulded fibreboard products. It is an aggregate comprising hardboard, medium density fibreboard (MDF) and other fibreboard. It is reported in cubic metres solid volume.

Paper and Paperboard

The paper and paperboard category is an aggregate category. In the production and trade statistics, it represents the sum of graphic papers; sanitary and household papers; packaging materials and other paper and paperboard. **It excludes** manufactured paper products such as boxes, cartons, books and magazines, etc. It is reported in metric tonnes.

Appendix III – FAO Production data for New Zealand

PRODUCTION – RAW MATERIALS

New Zealand production data was extracted from FAOStat and checked (Figure 11).

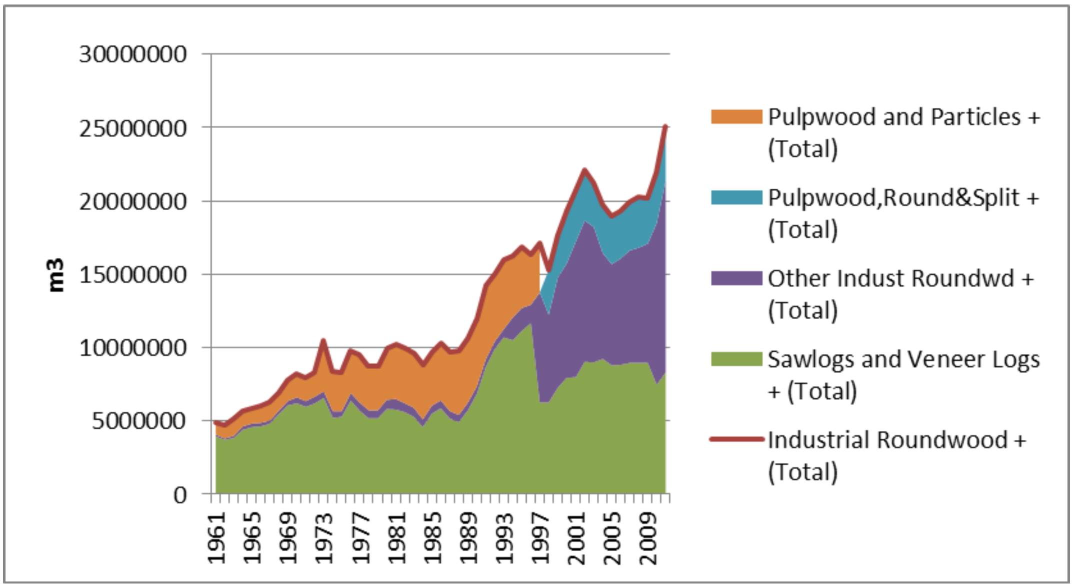

Figure 18. New Zealand roundwood production

It appears that from about 1992, the volume of export logs has been attributed to other industrial roundwood. This is the correct allocation for trade data but not for production. In a previous study (Wakelin et al 2008) an estimate of other industrial roundwood production was made with the remainder assigned to sawlogs and veneer. Corrected "other industrial roundwood" production is shown in Table 13.

Table 17. Assumed Other industrial roundwood production (i.e. posts and poles)

	Corrected "Other industrial roundwood" production (m^3)		Corrected "Other industrial roundwood" production (m^3)
1992	320000	2002	400000
1993	320000	2003	400000
1994	320000	2004	400000
1995	320000	2005	400000
1996	320000	2006	400000
1997	320000	2007	400000
1998	320000	2008	400000
1999	320000	2009	400000
2000	380000	2010	400000
2001	400000	2011	400000

Production is dominated by coniferous species, averaging 97% of annual production over the period from 1961-2011. There may be some missing non-coniferous pulpwood data – the value is zero for 1961-67, and also zero for 1998 when reporting switches from “Pulpwood and particles” to “Pulpwood, round and split”. There are also estimates for wood fuel but these appear to be approximations and are not available after 1997. They are not used required for HWP accounting.

The FAOSTAT data is not broken down further by species. Based on separate MPI estimates (Figure 12), the contribution from natural forests has declined from 33% in 1961 to 0.1% in 2011. The estimated total roundwood removals are reasonably consistent with FAO industrial roundwood production (Figure 13), but are not available by species. Some information on production of semi-finished wood products by species is available and was used as a proxy to estimate weighted density.

Radiata pine dominates planted forest production. By 1961 about 95% of production was radiata pine, although this later decreased as over-mature stands of less successful species were felled. Estimates of harvesting by species are available from the National Exotic Forest Description from 1995, showing an increase in the radiata proportion from 85% to 95% in this period.

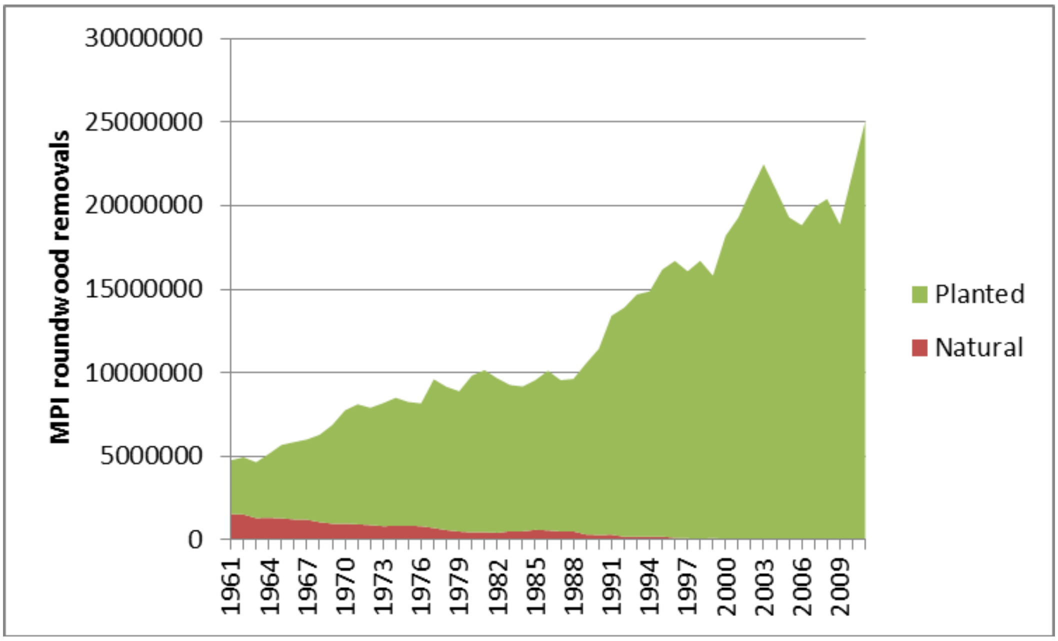

Figure 19. MPI estimates of roundwood removals from planted and natural forests

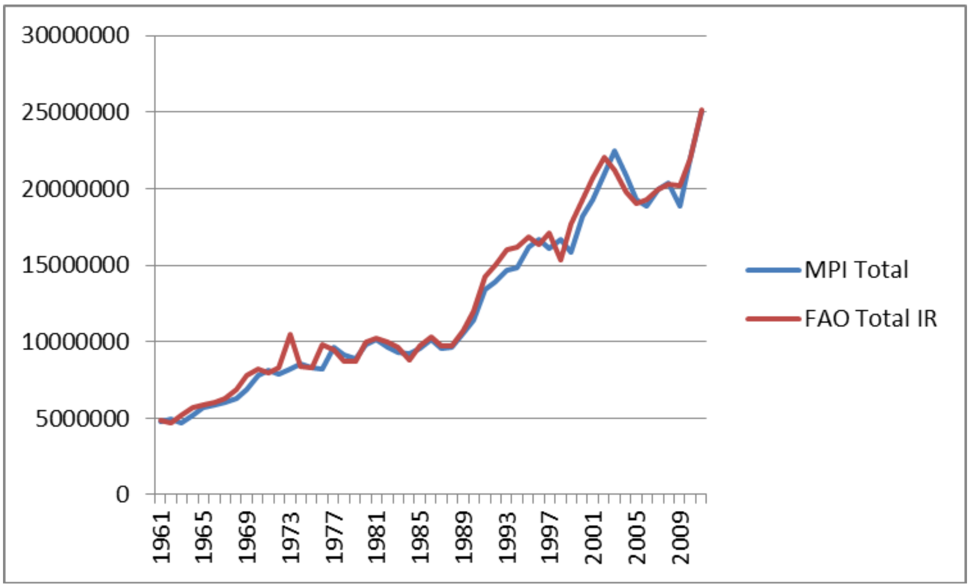

Figure 20. MPI roundwood removal estimates compared with FAO Total Industrial roundwood production

Production of woodchips is captured within the pulpwood and particles product until 1997 (Figure 14). After this a distinction is made between "Pulpwood, round and split" (which includes chips made directly from roundwood) and "Chips and particles" (which does not). The latter category would already be captured in industrial roundwood production data. Some information on wood chips by species is available from MPI data, but wood chips are only of interest if exported so discussion is in that section.

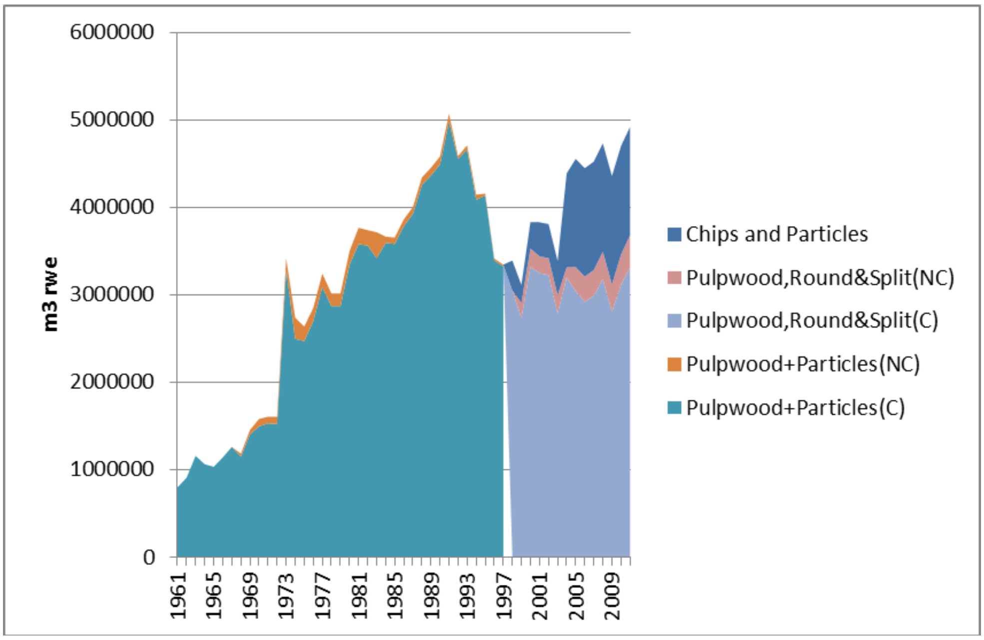

Figure 21. Production of pulpwood and wood chips

New Zealand's pulp production is evenly split between mechanical and chemical pulps, with only minor production of dissolving and semi-chemical pulps (Figure 15).

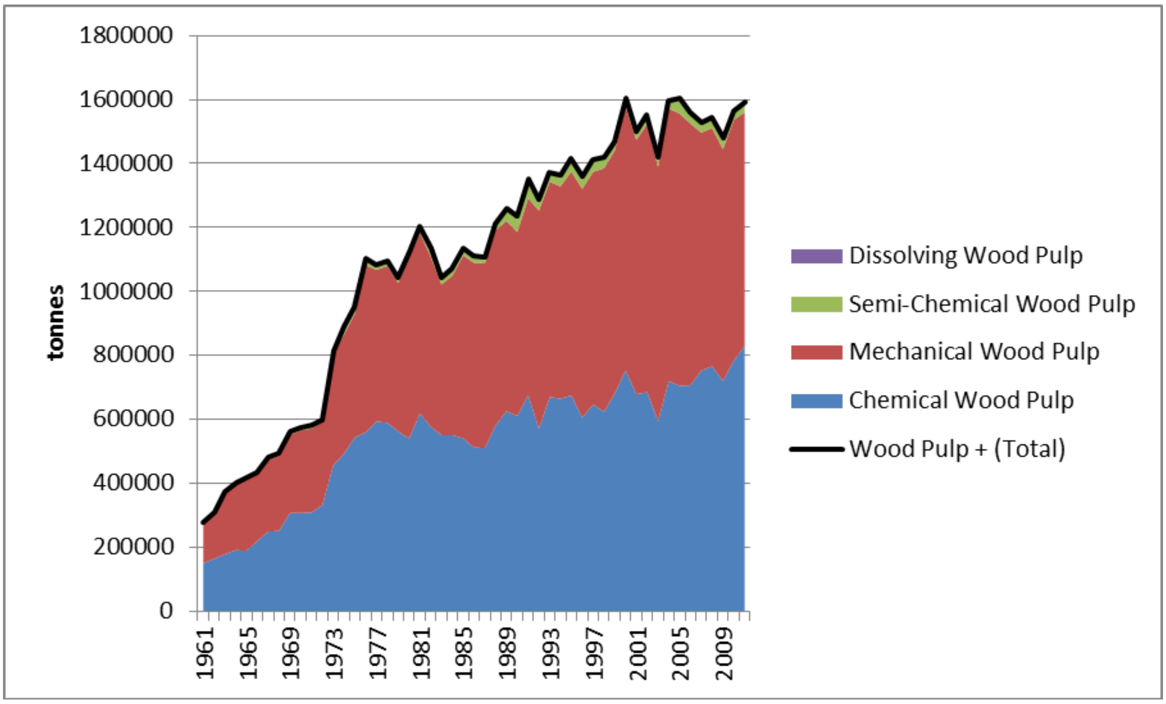

Figure 22. New Zealand pulp production

PRODUCTION – SEMI-FINISHED HWPS

FAO Sawnwood production data is dominated by coniferous timber, and has almost tripled since 1961 (Figure 16). MPI data shows a steady decline in sawn timber from natural forest over the slightly longer period from 1951 (Figure 17), with rimu/miro the main species throughout. When combined with the planted forest sawntimber estimates (Figure 18) the combined dominance of rimu/miro and *Pinus* species is clear.

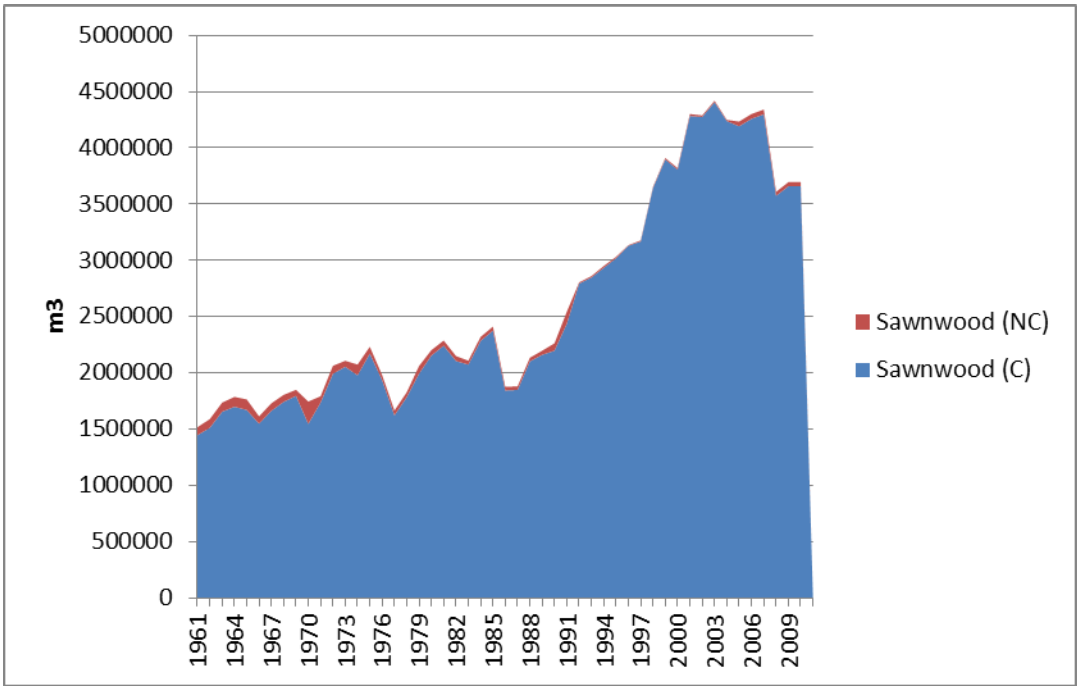

Figure 23. New Zealand sawnwood production

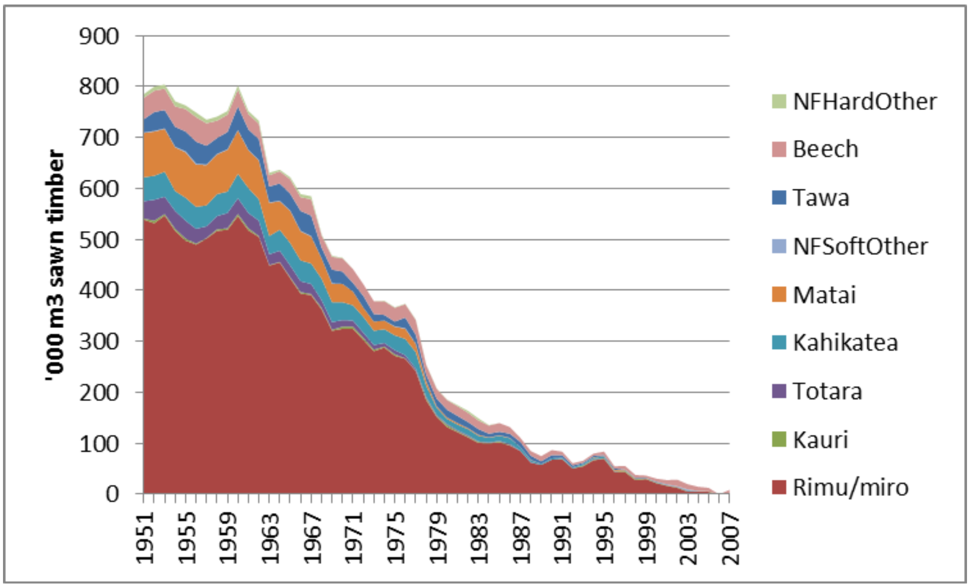

Figure 24. Sawn timber production from natural forests by species

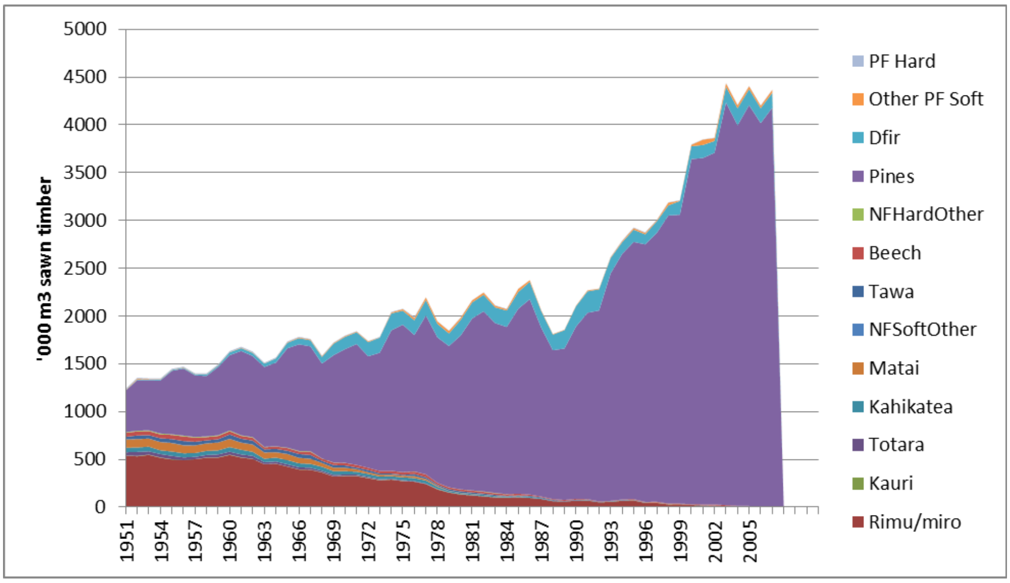

Figure 25. Sawn timber production from natural and planted forest species

MDF production began in 1976 and together with plywood and veneer sheets makes up most of the panel production (Figure 19). Small quantities of logs from natural forest contribute to veneer production but radiata pine is the main feedstock. According to MPI data, since 2003 on average 54% of annual plywood production has been LVL.

Early non-newsprint paper and paperboard production is not disaggregated, but overall production is dominated by newsprint (average 43% of total) and the aggregate wrapping paper, packaging paper and paperboard category (average 45%). The latter category has been disaggregated into Wrapping papers, Other papers packaging, Case materials and Folding boxboard since 1998, with case materials (containerboard) providing most of the productions (Figure 20). Tawa and later eucalyptus species have been used to provide short fibres for pulping, but the pulp and paper industry is closely associated with the radiata pine.

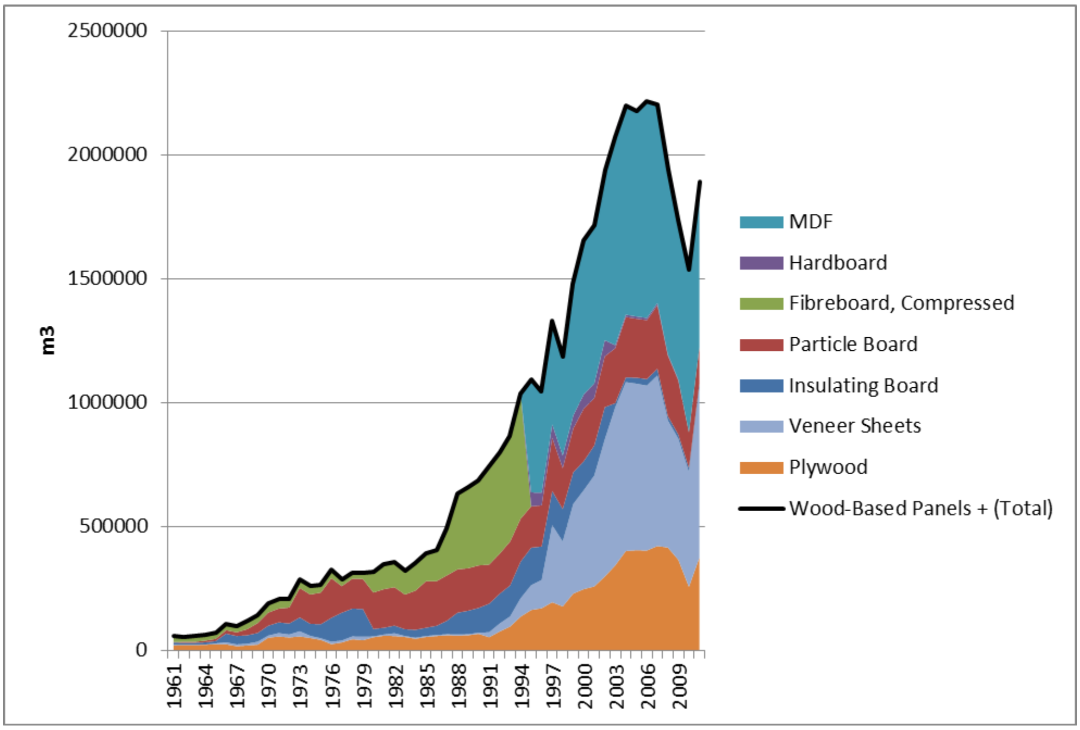

Figure 26. New Zealand wood-based panel production

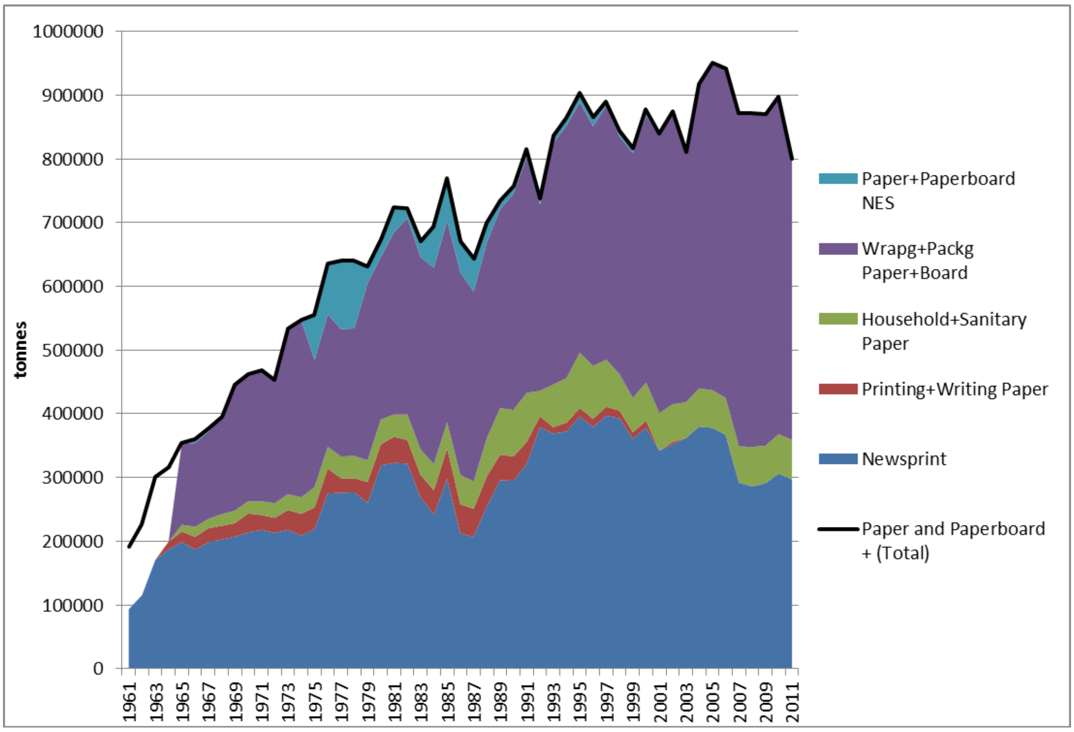

Figure 27. New Zealand paper and paperboard production

Appendix IV – FAO Import data for New Zealand

IMPORTS – RAW MATERIALS

The main wood product raw material imported into New Zealand since 1961 is chemical pulp (Figure 21), but it makes a relatively small contribution to pulp supply. The average ratio of domestic pulp production to imported pulp over the period is 116:1 (or 79:1 for the years 2009-2011).

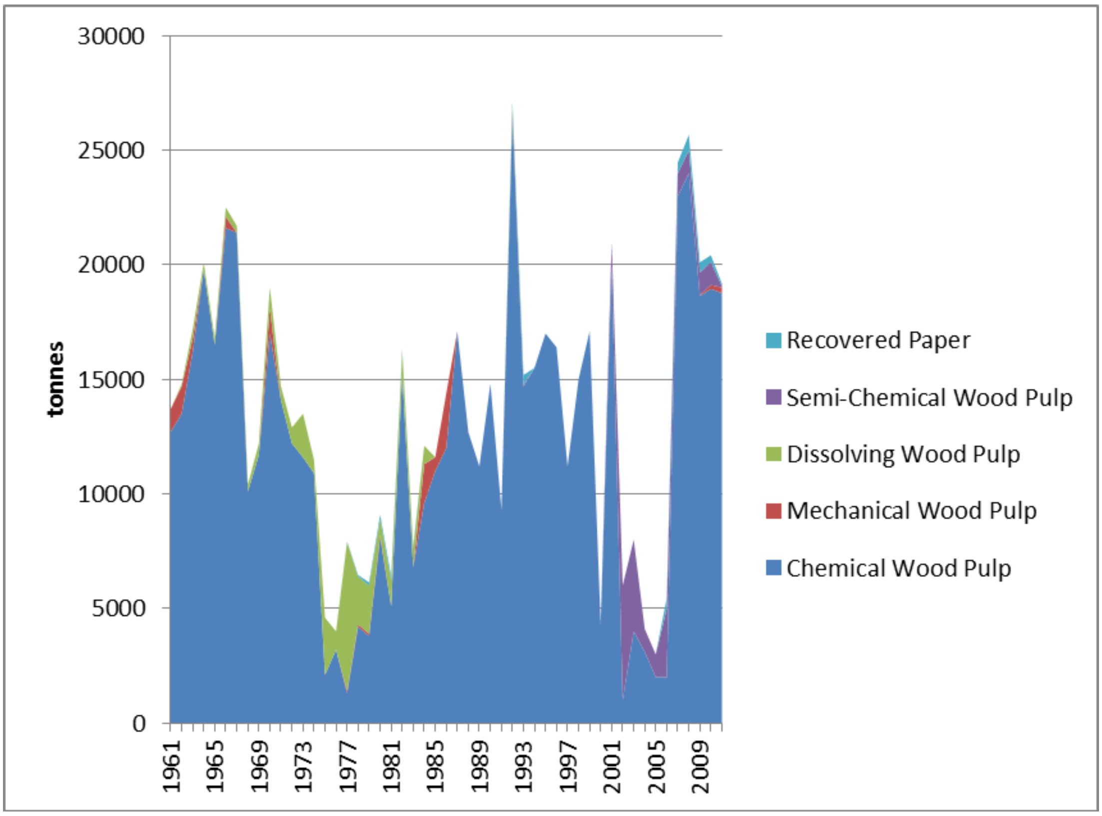

Figure 28. New Zealand pulp imports

Domestic industrial roundwood production is far greater than imported roundwood, with an average ratio of 3104:1 (or 8361:1 for the years 2009-2011). In most years 60-90% of the roundwood imports were "Other Industrial roundwood", assumed to be mainly Australian hardwood poles. After 1989 this category is no longer disaggregated. Small quantities of veneer and sawlogs are imported as are veneer sheets (Figure 22). Little if any imported veneer appears to be captured by New Zealand plywood production statistics, because it is used directly in joinery and furniture. Residues from discarded imported HWPs and recycled imported paper could also be used in the production of HWPs in New Zealand, but the contribution would be minor. Imports of wood chips are negligible.

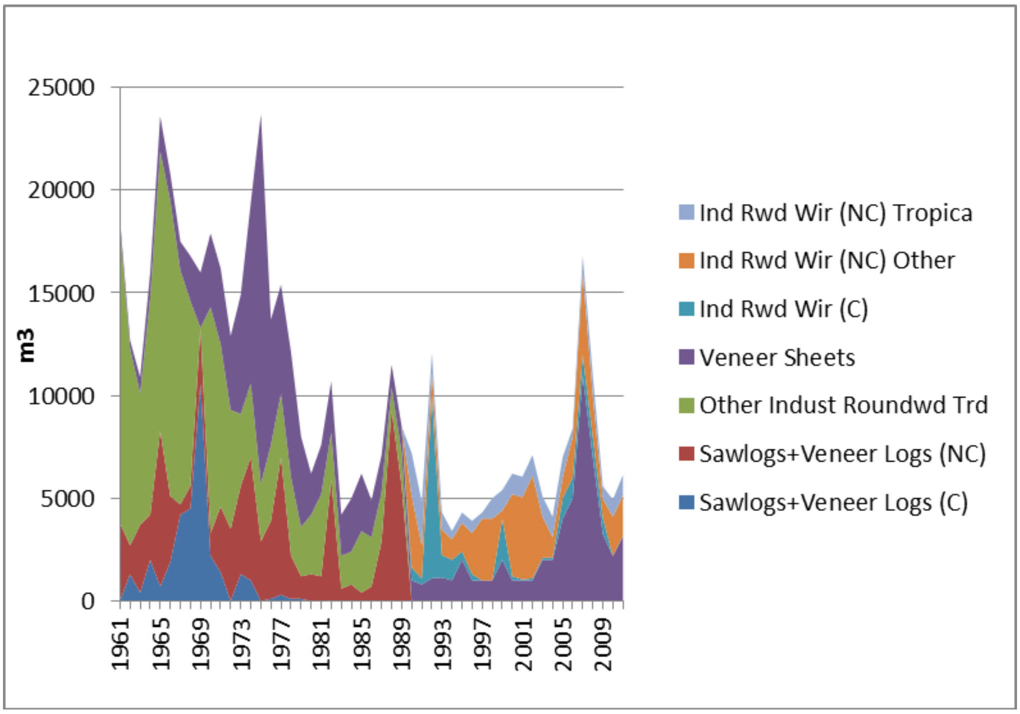

Figure 29. New Zealand roundwood and veneer sheet imports

IMPORTS – SEMI-FINISHED HWPS

Domestic production of sawn wood, panels and paper and paperboard also outweighs imports, though not to the same extent as with raw materials. Sawn timber exports have been relatively stable, with the ratio of domestic production to imports of 70:1 (99:1 for 2009-2011). However, imports of panels and paper have been increasing (Figure 23). Over the period since 1961, the ratio domestic production of panels to imports has average 62:1 (32:1 for 2009-2011) while the equivalent ratio for paper is 9:1 (2:1 for 2009-2011). This suggests that recycled imported paper could become an increasing proportion of fibre furnish for paper production in New Zealand.

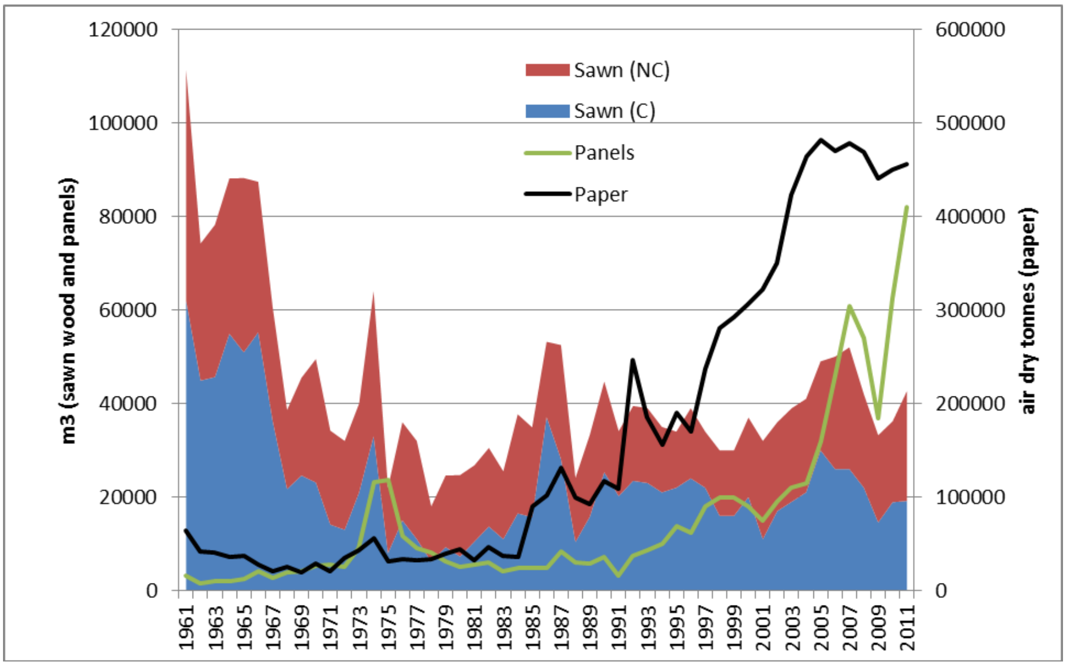

Figure 30. Imported sawn wood, panels and paper and paperboard

Appendix V – FAO Export data for New Zealand

EXPORTS OF RAW MATERIALS

Export of industrial roundwood

Log export background

In 2012, New Zealand's planted forests produced 26 million m^3 of roundwood, of which 50% was exported as logs (FAO 2012). The export log market is an essential part of the New Zealand forest industry. There is a place for log exports even when the domestic wood processing industry is internationally competitive, as there may be supply fluctuations due to significant wind throw events, shut-downs at major plants, or down turns in domestic demand (Katz 2004). Export markets may also take species or grades that are not in high demand locally and encourages efficiency in domestic processors through competition.

In New Zealand's case the investment in plantation development has not been matched by an investment in world-scale processing capacity and it is difficult for local processors to compete internationally. Operating conditions for New Zealand have been difficult, with high manufacturing costs, a strong New Zealand dollar and the debt crisis depressing the global housing market. There has also been increased competition from the EU in the Australian sawn timber market (MPI 2012). This has lead to mill closures and unused capacity at a time when wood availability from New Zealand's planted forests has been increasing. As a result, the proportion of the annual harvest exported in log form has been increasing.

In 2011, New Zealand provided 1.6 per cent of the world's supply of industrial roundwood but about 13%of internationally traded industrial roundwood. Asian markets take over 99 per cent of New Zealand's export logs. China and South Korea alone imported 58 per cent and 19 per cent, respectively in 2012 (Ministry for Primary Industries, 2012). India now imports a similar volume to Japan, which was formerly the main market. Log exports are likely to remain high during the second Kyoto commitment period (2013-2020) (see section 6).

FAOStat total roundwood exports: 1961-2011

Exported roundwood for 1961-2011 was obtained from FAOStat and is shown in Figure 24. From 1990 the sawlog and veneer log and pulpwood categories in trade data were amalgamated as Industrial roundwood (wood-in-the-rough). This is further divided into coniferous and non-coniferous. The small peak of exports in the 1960s was followed by a low level maintained until the late 1980s when the log export trade began to increase rapidly.

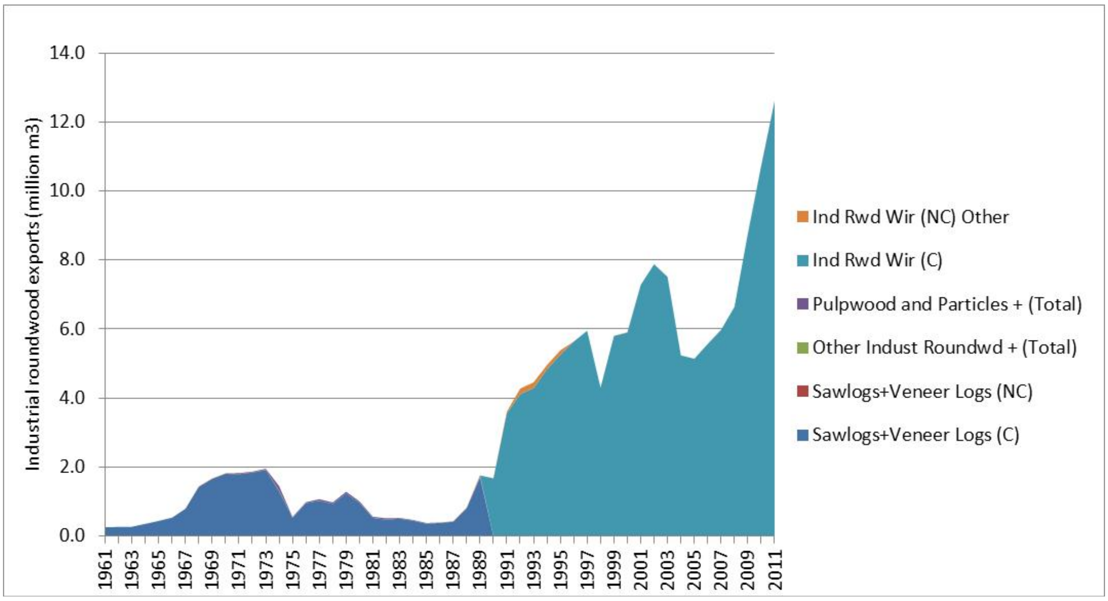

Figure 31: New Zealand exports of industrial roundwood (FAOStat). Note: from 1990 the sawlog, veneer and pulpwood categories in trade data were amalgamated as Industrial Roundwood wood-in-rough (Ind RW wir).
C = coniferous; NC = non-coniferous

Trade data for "pulpwood and particles" includes chips, particles and residues as well as pulp logs. Exports are clearly dominated by coniferous logs.

Export log grades

The amalgamation of traded logs to a single category ("Industrial roundwood, wood-in – rough") provides little insight into potential HWP production. To better understand the complexity in the export log market it is necessary to focus on the log specifications. Log specifications are important as they determine how closely logs will match the requirements of processing and end uses for overseas markets. Consequently log specifications have become a key part of sales contracts (Katz, 2005). The characteristics used to demarcate logs are principally log size (i.e. diameter and length), and quality traits (e.g. straightness, knot size and frequency, sweep and ovality).

There have been several unsuccessful attempts to standardise log grades across the global industry. Difficulties in achieving a consensus are largely due to differences in consumer preference and species traits. Katz (2005) provides a high level view of the match of radiata log types to key markets and end uses (Table 14).

Table 18: General export log specifications (based on Katz (2005))

Major Log Type	Country	Normative Grade	Common End Uses
Pruned	Korea, China	P1/P2, Z1Z/Z2Z	Furniture, Veneer
Large sawlog	Japan, Korea, China, SE Asia, India	A, SOM	Packaging, Shuttering, Furniture, Plywood
Medium sawlog	Korea, Japan	K/J, SOM/SMM	Packaging, Shuttering, Plywood
Small sawlog	Korea	KS, SOM/SSM	Packaging, Shuttering, MDF
Industrial sawlog	Korea, China, SE Asia, India	KI, SKX	Packaging, Shuttering, Plywood
Pulp	Japan, Korea, China, SE Asia, India	Pulp, UBR/UHR	Panels, Pulp

Katz (2004) lists four broad market segments for imported logs from New Zealand: packaging (including pallets, cable drums, boxing and crates); temporary construction (including concrete formwork and civil engineering uses); furniture and fittings (including windows, doors and mouldings); and plywood.

The export trade for plantation logs from New Zealand began in the late 1950s with exports to Japan, where demand for New Zealand logs is primarily for packaging and plywood. Japan remained the main destination for New Zealand logs until the sudden rise of the Korean market in the 1990s, where temporary construction was also important. The main competitor for New Zealand radiata pine logs in Korea and China is Russian larch. The imposition of a tax on Russian log exports in 2008 allowed New Zealand to gain significant market share, and rapid economic growth in China saw that market become the top importer of logs from New Zealand in 2005. India is also a growing market, currently taking radiata pine for packaging and temporary construction. These four markets currently take almost 99% of New Zealand's log exports. Developments in key markets are described in Appendix 2.

No time series of exports by log grade is available. FAOStat bilateral trade data provides information on the destinations of logs, but no further information on log grade that would help to determine end use.

FAOStat bilateral trade data for NZ roundwood exports: 1997-2010

Table 15 and Figure 25 present the FAOStat data for New Zealand exports of coniferous logs to other countries. The data series only covers the last 14 years and there are numerous errors requiring adjustments. Nevertheless the declining importance of the Japanese market and rise of the Chinese market is apparent.

Table 19: Industrial roundwood wir (coniferous) exports from New Zealand

	Markets						
	China	India	Japan	Korea	Others	Others (adjustment)	Unspecified
1997	29987	368595*	1982644	2579997*	148574	3229795	0
1998	139433	263718	1853749	1845908	201192	0	0
1999	307100	372931	1610000	3654951	55018	0	0
2000	472573	254741	1657000	2958437	254919	0	172330
2001	1033785	95159	1580254	4180000	213091	-20000	200711
2002	1653916	295127	1515930	3934146	368003	0	86878
2003	2028490	254300	1427565	3342164	258528	0	218953
2004	778773	172892	1515608	2540210	94198	-791	136110
2005	794367	419462	1120224	2585381	157429	95653	64484
2006	1246739	347436	1148335	2331227	231447	-428992	264808
2007	1647000	430000	813000	2764000	210997	1986519	-1873516
2008	2141000	594000	812000	2963000	249298	-181054	104660
2009	6259000	938000	36000	1525000	122592	-1000	-112592
2010	6298000	1265000	737000	2390000	154661	-246167	138695

** no value in FAO data, so estimated based on share of export logs in 1998.*

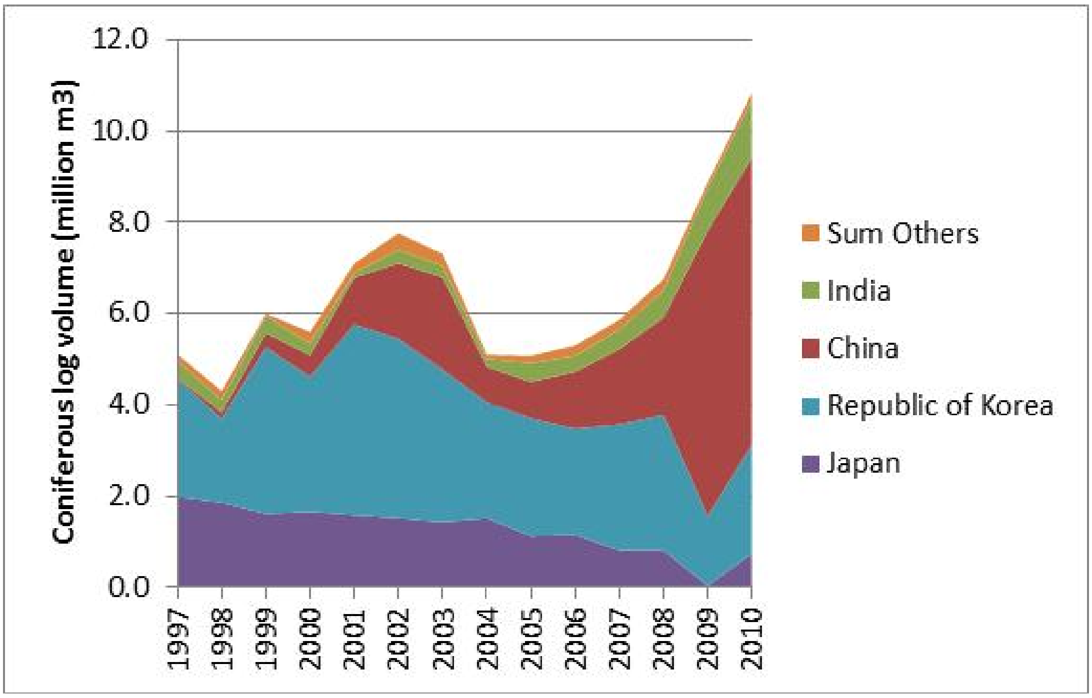

Figure 32: Industrial roundwood wir (coniferous) exports

Table 16 and Figure 26 present the FAOStat data for New Zealand exports of non-coniferous logs to other countries. Volumes sent to the four main coniferous log markets are small by comparison with coniferous exports. The larger values appear to be errors.

Table 20: Industrial roundwood wood-in-rough (non-coniferous) exports

	China	India	Japan	Republic of Korea	Sum Others	Others (adjustment)	Unspecified
1997	82644		2001		6807	0	0
1998	64310		8	157433	85708	0	0
1999	9451		2663	155989	43507	0	0
2000	64658		3	10865	195025	-266551	0
2001	119860		4409	3860	217839	-344568	0
2002	53060		98	4355	11211	-58724	0
2003	6998	129706	203	3598	172033	-300544	6
2004		74461	9000	826713	2E+08	-2.2E+08	0
2005	5840		443	505	45393	-54348	8167
2006	8499		5696	1319	92996	-114539	10029
2007	32137	1E+06	1650	1750	49072	-1256961	887
2008	1526	1E+06			56827	-1518056	0
2009	2406	650			7693	-10255	106
2010	8400	3367		758	21176	-17628	101

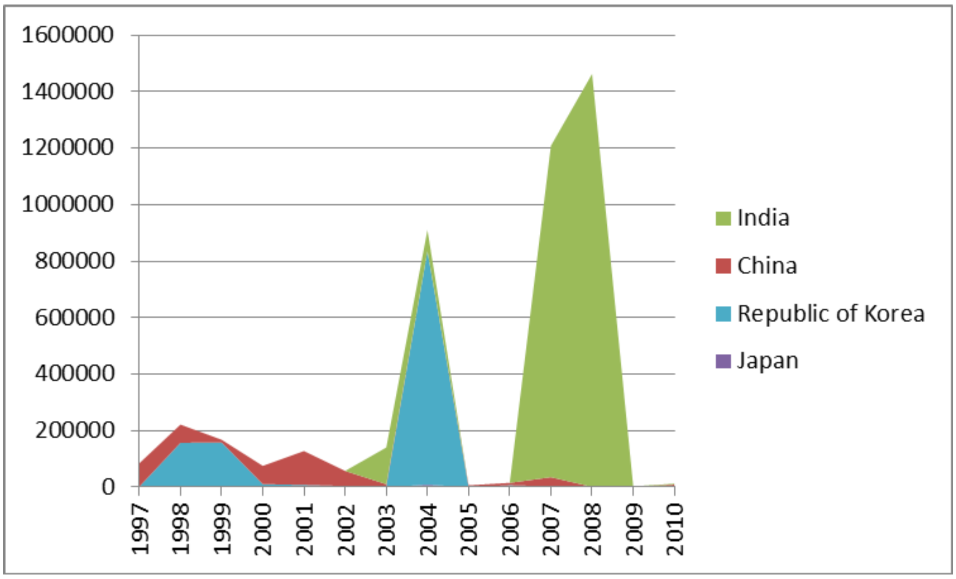

Figure 33: NZ industrial roundwood wir (non-coniferous) exports (m^3)

FAOStat bilateral trade data for roundwood imports from NZ: 1997-2010

The bilateral trade data allows a comparison to be made between the logs New Zealand reports to have exported to each trading partner and the logs each trading partner records as having imported from New Zealand.

There are large discrepancies between imports and exports reported in FAOStat (e.g.Figure 27). The difference between log exports as reported by NZ and the imports as reported by China is, on occasion, several million cubic metres of raw wood. In other cases there are even greater errors, such as New Zealand exports of 219,383,250 m^3 of non-coniferous Industrial roundwood to Australia and 523,074,951 tonnes of chips and particles to Japan, both in 2004.

Figure 34: Total difference between reported import and export stats for India, China, Japan and Korea for a range of harvested wood products and raw timber.

In the following charts, reported imports and exports from FAOStat data are compared for the main markets, together with separate MPI data. The MPI data is June year data for 1981-2000 from statistics published by MAF (MAF 2001) and calendar year estimates for 2002-2011 from the MPI website.[22] Data for the 2001 year is missing. The FAOStat estimates combine coniferous and non-coniferous logs. Non-coniferous 'tropical' logs are included where they occur.

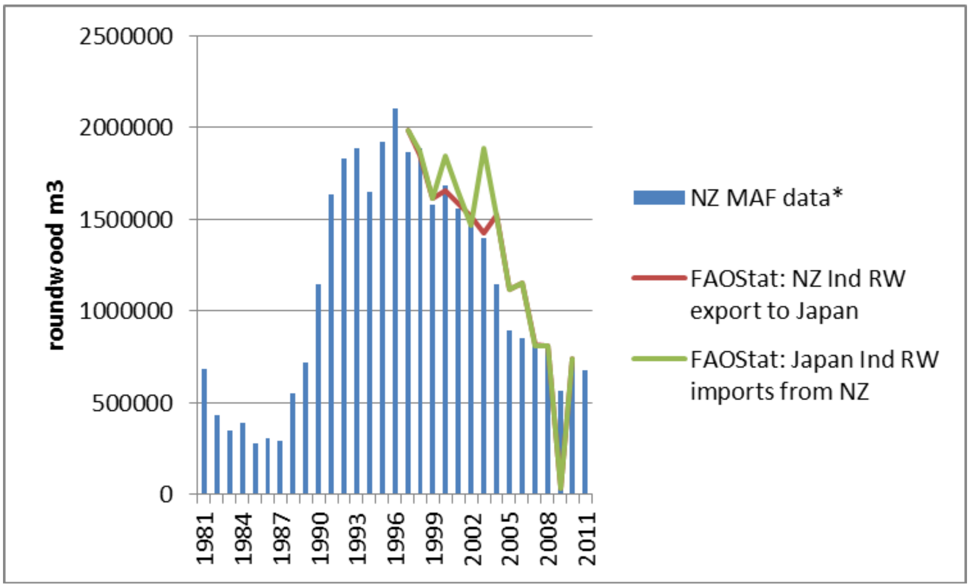

Figure 35: MPI and FAOStat Trade data: NZ-Japan (m3)

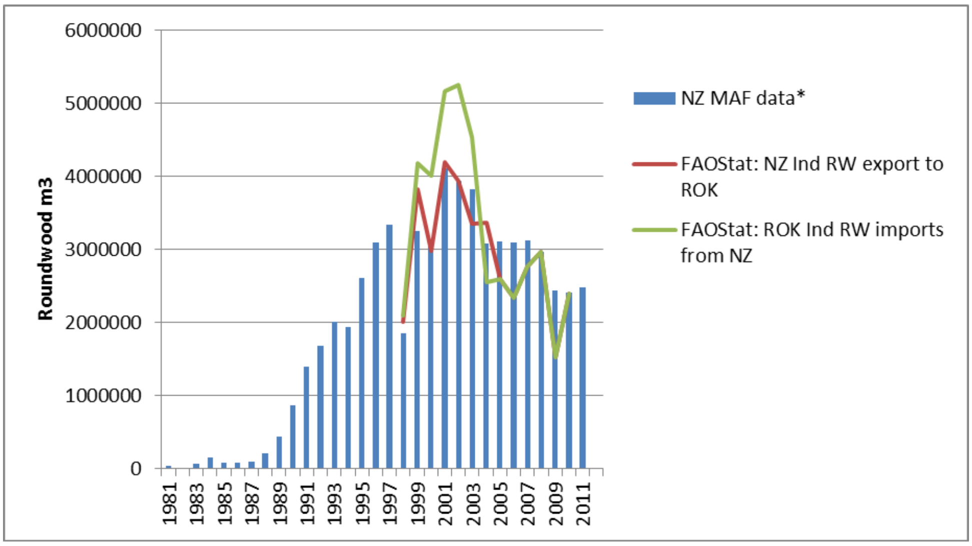

Figure 36: MPI and FAOStat Trade data: NZ-Korea (m3)

[2222] http://www.mpi.govt.nz/news-resources/statistics-forecasting/forestry/annual-forestry-export-statistics.aspx

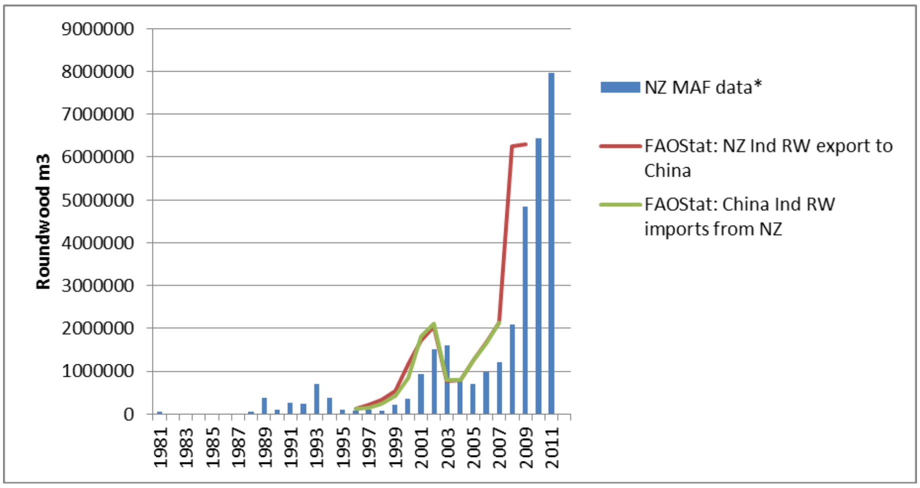

Figure 37: MPI and FAOStat Trade data: NZ-China (m^3)

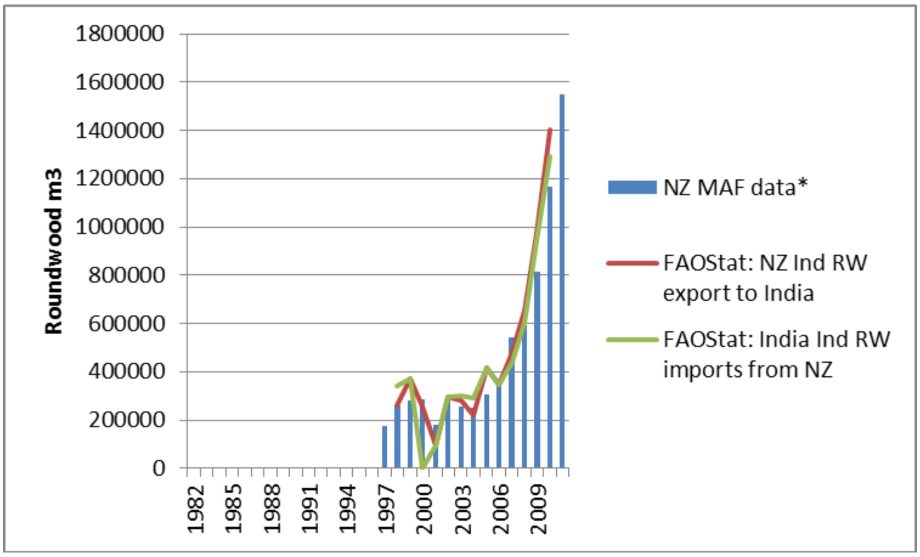

Figure 38: MPI and FAOStat Trade data: NZ-India (m3)

India was included within the "Other countries" category in the data published for 1981-2000 (MAF 2001).

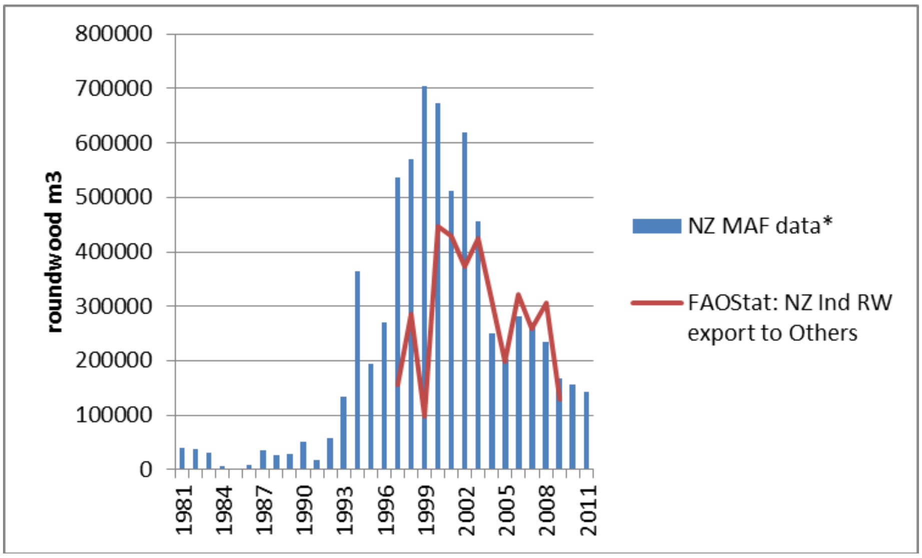

Figure 39: MPI and FAOStat Trade data: NZ-Other countries. Note India is included within "other countries" before 2002.

Overall, the three data sources show similar trends and are of a similar order of magnitude. Shipping time to India is about thirty days, so it is possible for logs to be exported from New Zealand in one year but arrive the following year. The FAOStat data has been criticised for the persistence of errors, which make it difficult to use the data for analyses such as illegal logging.[23]

Exports of wood chips and pulp

Wood chip and pulp export background

The wood chip export trade began in 1969, with chips from native and plantation forests exported from Nelson (*New Zealand Yearbook*). The principle market through the first three decades was Japan, which took up to 80% of traded wood chips (Fenton 1982).

Export of chips from native forests (mainly beech) was controversial and peaked in 1987 before ending in 2001. During the 1980's the proportion of wood chips derived from native forests averaged about 45%. Eucalypt forests have been established in Southland specifically for the wood chip export industry, so New Zealand continues to export both softwood and hardwood chips.

Pulp exports began with the development of pulp and paper mills at Kinleith and Kawerau. Pulp production and exports have been evenly split between chemical and mechanical pulp since the mid-1970s. Japan was traditionally the main market but has been overtaken by Korea and China.

FAOStat total wood chip and pulp exports: 1961-2011

Figure 33 compares FAOStat data for New Zealand's total exports of chips and particles with estimates from other sources. FAO data is expressed as m^3 roundwood equivalent (rwe), as is MPI production data. The MAF (2001) data was expressed as bdu for all sources combined, so this was converted to rwe using the factors of 2.31 for planted forests (radiata) and 2.25 for natural forests (beech) (MAF 2001). These factors were also used to convert the Japanese MAFF data presented by Howtec (2010) from bdt to rwe. Fenton (1982) provides an additional source for New Zealand chip exports in rwe. The data sources in Figure 33 vary in year ending convention and have not been converted to a common basis.

[23] http://www.globaltimber.org.uk/rwevolume.htm

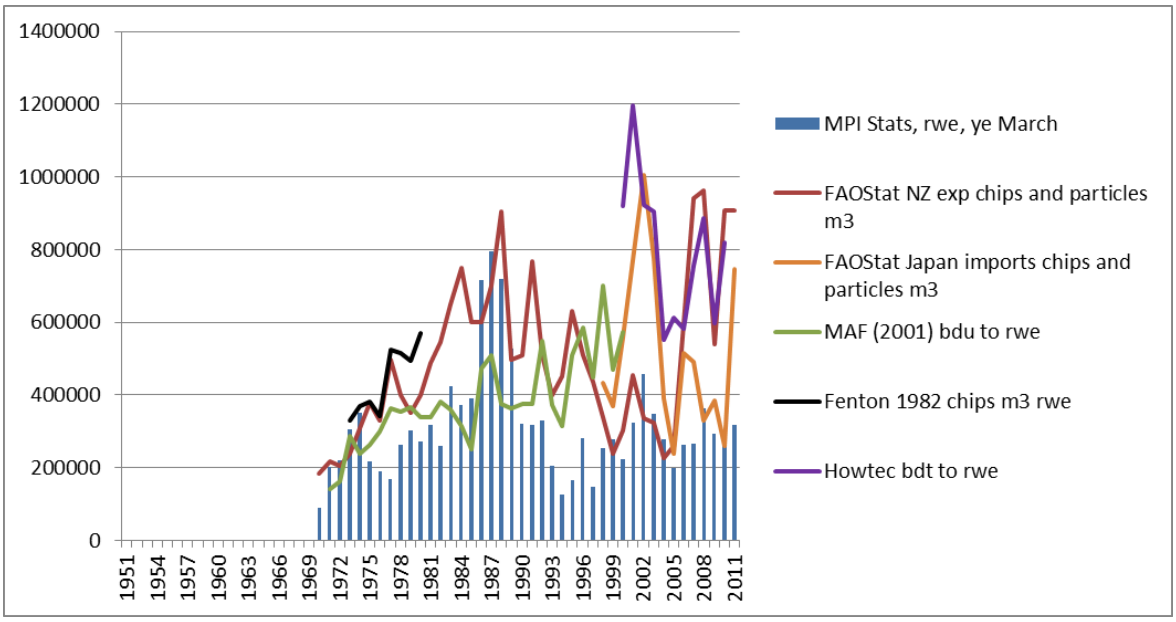

Figure 40: New Zealand exports of chips and particles (FAOStat)

Figure 34 shows pulp exports by type of pulp from the FAOStat data. Recycled paper exports are also shown, but would be captured in the New Zealand paper production data. In Figure 35 the data series is extended to the start of pulp exports in 1954 using New Zealand year book data. Dissolving pulp is excluded from accounting as it is not used for making paper (quantities are limited) and semi-chemical pulp is combined with chemical pulp. The MAF (2001) data is consistent with the FAOStat data.

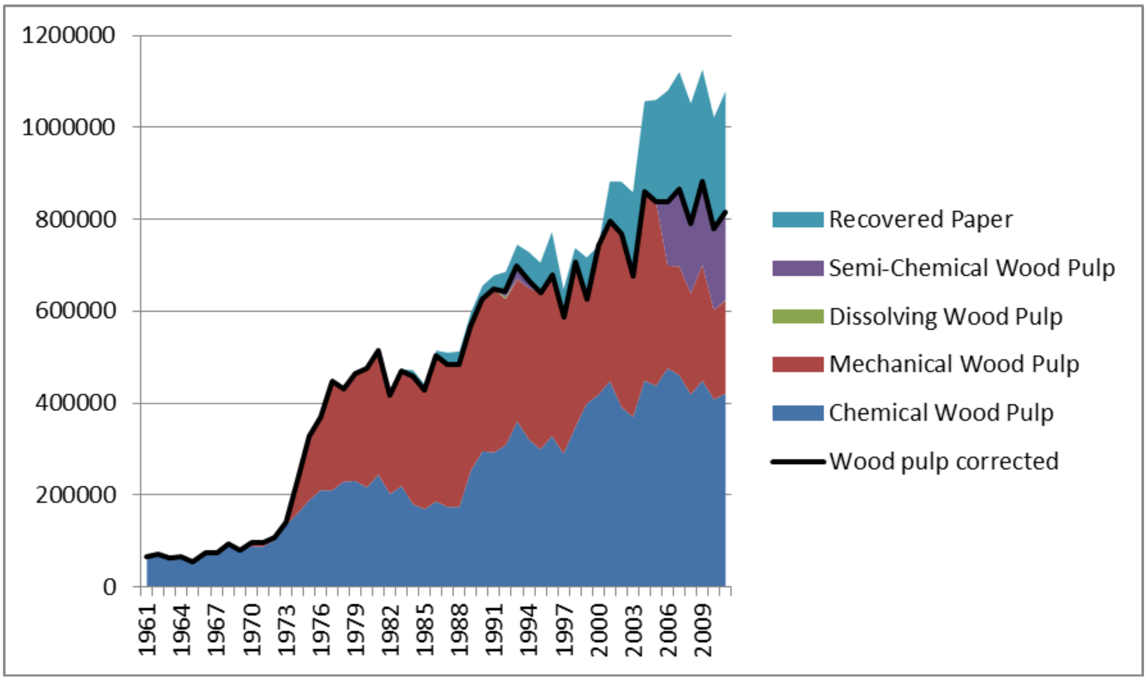

Figure 41: New Zealand exports of wood pulp (FAOStat).

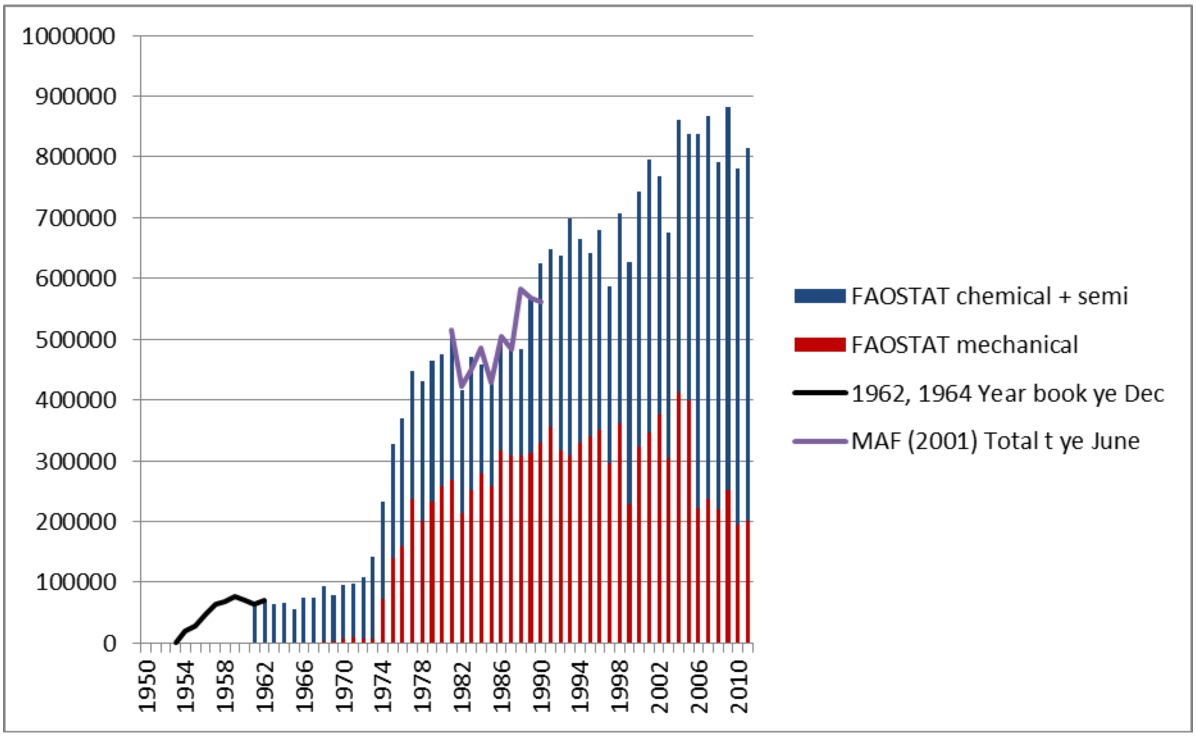

Figure 42: FAOStat NZ Pulp exports compared with other data

FAOStat bilateral trade data for wood chip and pulp exports: 1997-2010

Given the dominance of the Japanese market, the similar international conversion rates of wood chips to pulp and paper, and the short life span of paper and paperboard, there is little to be gained by allocating wood chip exports to individual markets. The same applies to wood pulp exports; the main markets for pulp are currently China, Korea, Japan, Australia and Indonesia, accounting for about 80% of exports. There are unlikely to be significant differences in the conversion to paper or paper life spans within those markets.

Conversion of raw materials to semi-finished HWPs is discussed in Appendix VI.

EXPORTS OF SAWN WOOD, PANELS AND PAPER/PAPERBOARD

HWP export background

Semi-finished wood products are exported from NZ to countries all over the world (Figure 36). Australia is the main trading partner for paper (45%) and sawn timber products (22%). The panel market is dominated by Japan (51%) and the pulp market by China (32%). In general markets are more diversified than for log exports, particularly for sawn timber.

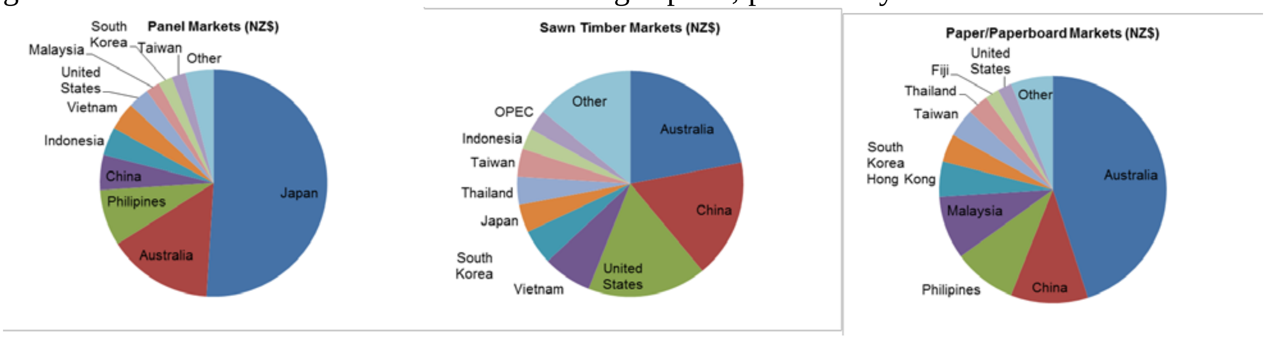

Figure 43: Semi-finished wood product export markets.

Exports of timber began in the early days of European settlement. Kauri forests were heavily exploited in the 19th century, with supply outstripping demand. Following a period of recession in the 1880s and 1890s production increased again, reaching a peak in 1907. As availability declined, attention turned to other species – principally kahikatea until supplies ran out in the 1940s then rimu. In 1931 radiata pine made up 2% of exported timber and this increased steadily to reach 50% in the 1940s. By the mid-1950s radiata made up over 90% of exported timber. The main sawn timber market has always been Australia, taking as much as 99% of exports. The Pacific Islands and the United Kingdom were the other main markets for much of the 20th Century.

Exports of panels and paper began later, with the development of major pulp and paper mills in the 1950s to utilise the planted forest resource, and the development of MDF production in the 1980s.

FAOStat total semi-finished HWP exports: 1961-2011

Figure 37 shows the exported semi-finished wood products exported to all countries from New Zealand. The dramatic increase in exports since the early 1960s is evident. Exports are dominated by sawn timber, which show the largest overall increase in growth.

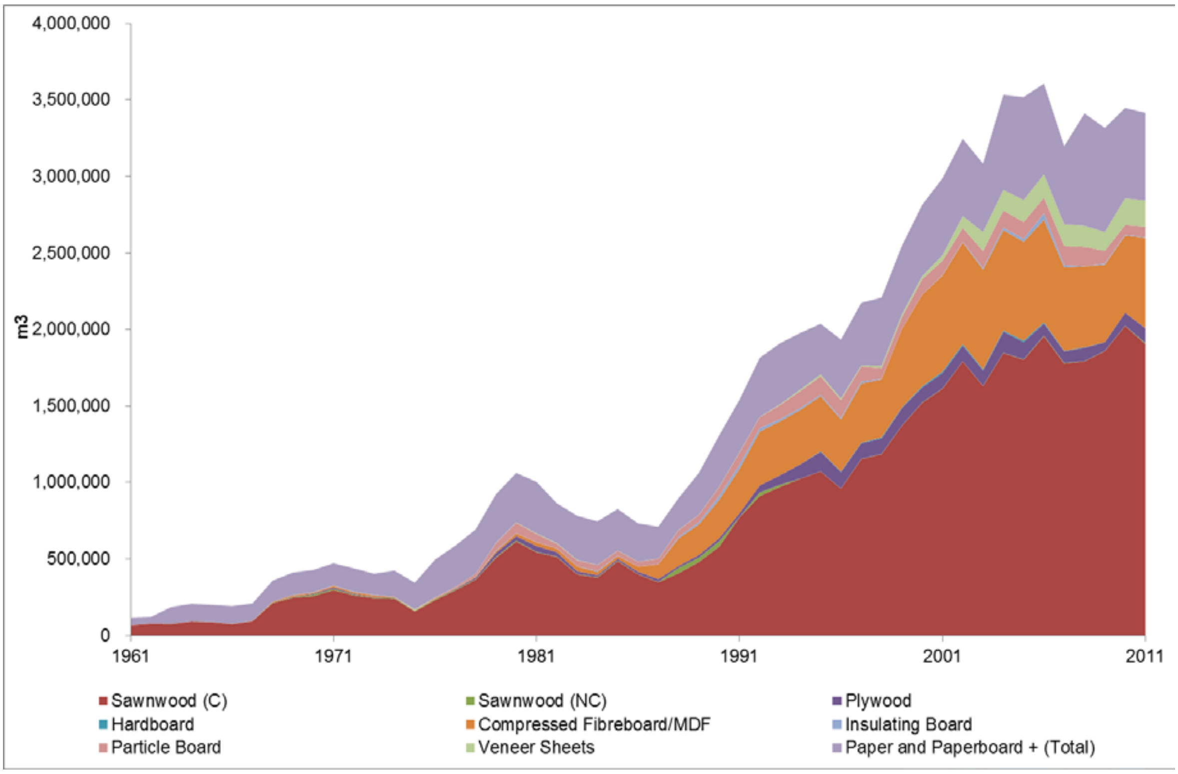

Figure 44: New Zealand exports of semi-finished wood products.

FAOStat semi-finished HWP exports by market: 1997-2011

Figure 38, Figure 39 and Figure 40 give the FAOStat bilateral trade data for exports of HWPs by market since 1997.

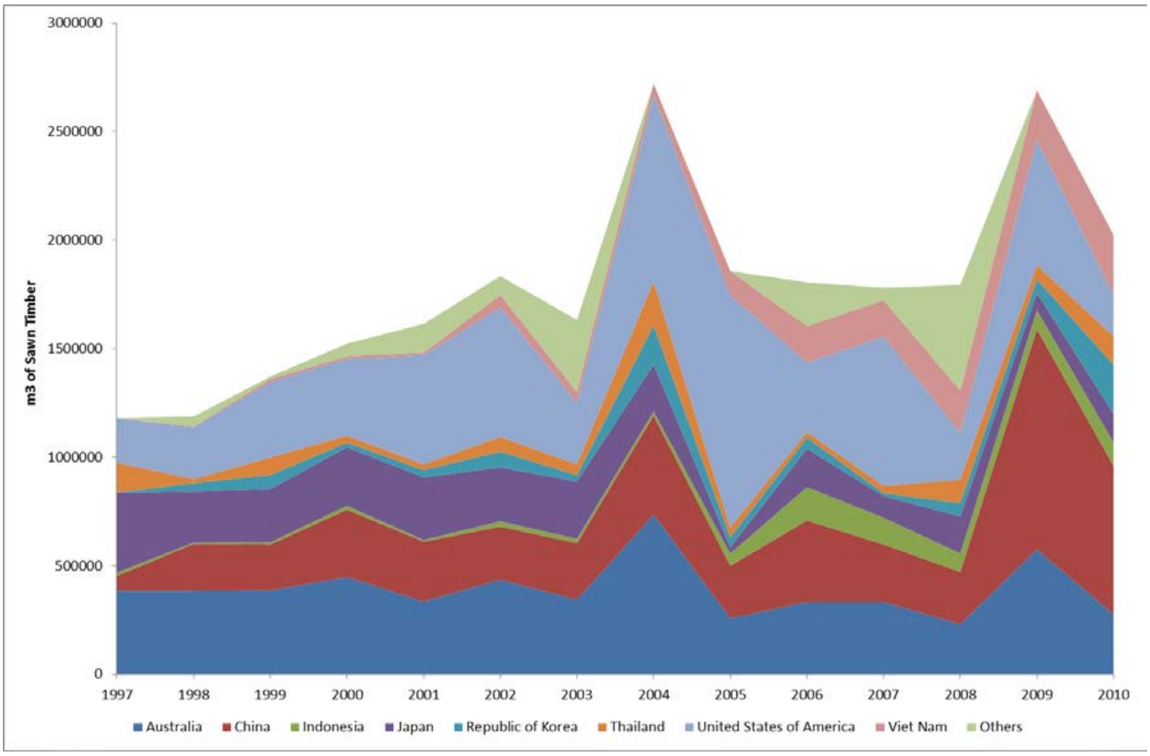

Figure 45: NZ exports of sawn timber by importing country 1997-2010.

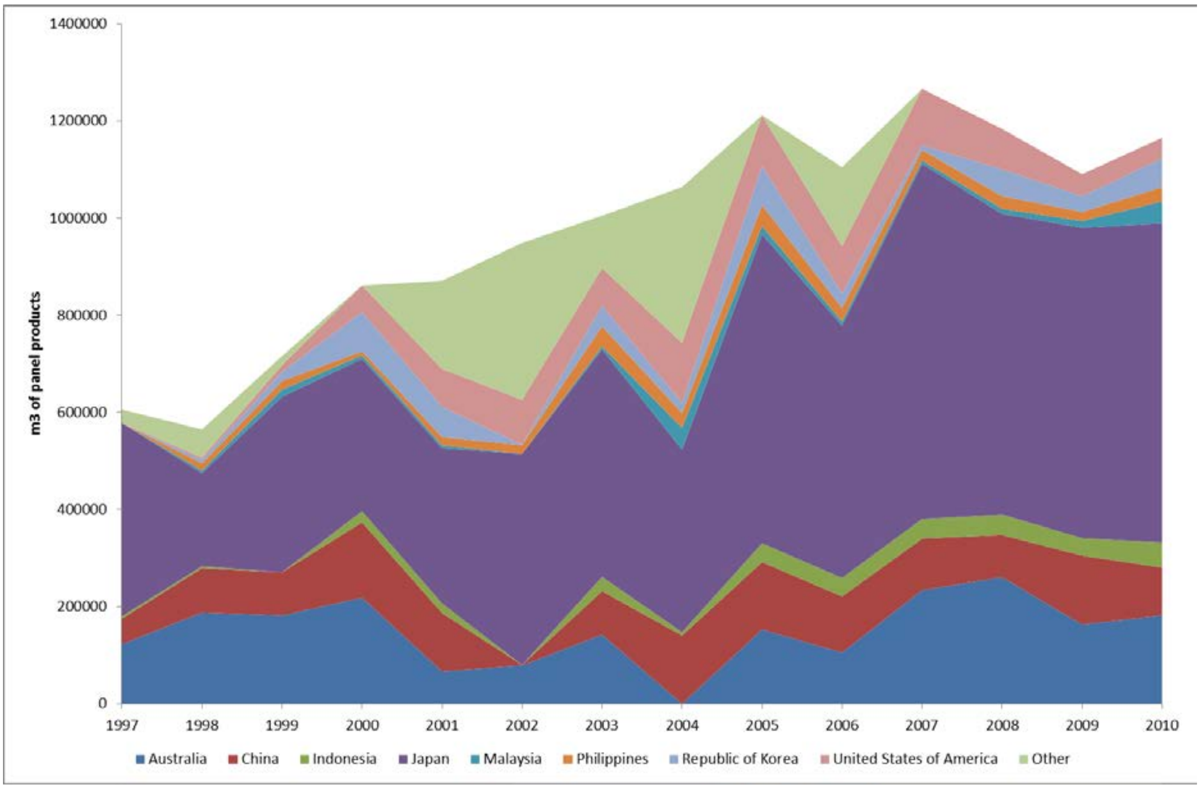

Figure 46: NZ exports of panel products by importing country 1997-2010.

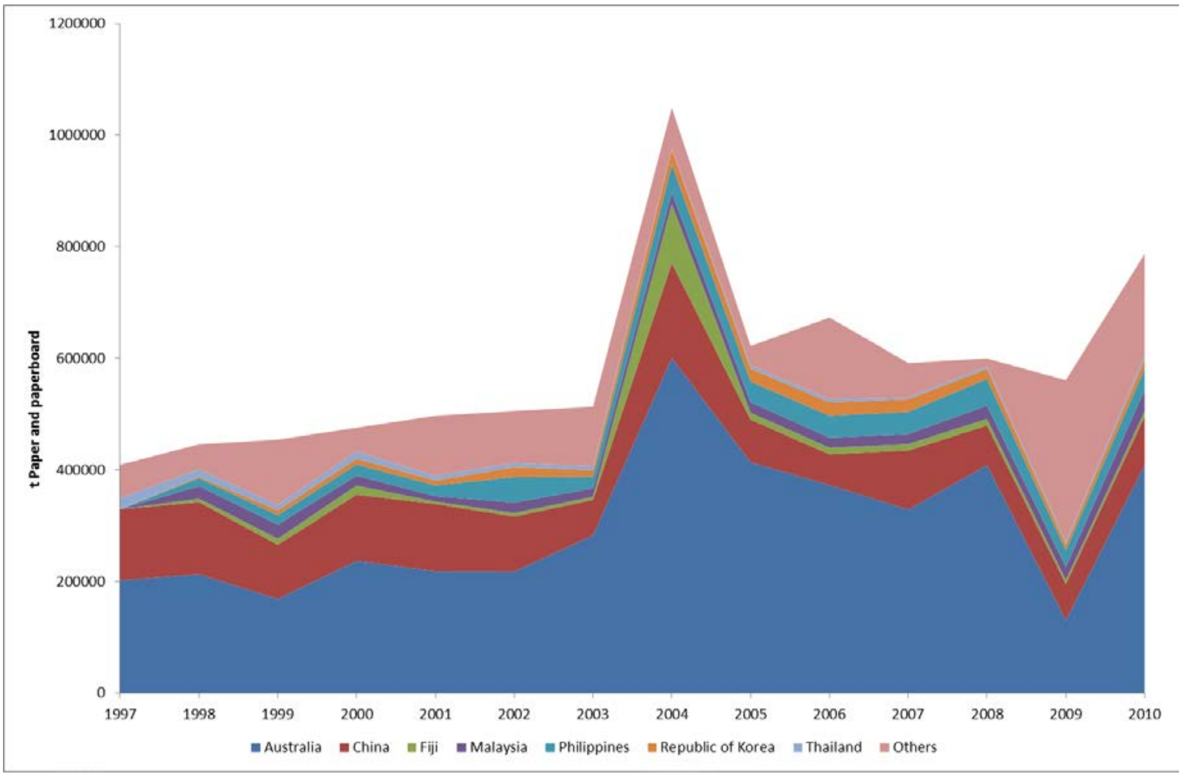

Figure 47. NZ exports of paper and paperboard by importing country 1997-2010.

Appendix VI - In-market production of HWPs from NZ raw materials

There are two broad approaches for calculating the transfer of carbon from the forest pools to HWPs: **direct** methods and **proxy** methods. Direct methods involve actual measurement or estimation of the carbon content in harvested wood products. Proxy methods instead use trends in forest product markets and supply chains to estimate the allocation to wood products. Figure 41 depicts the two options.

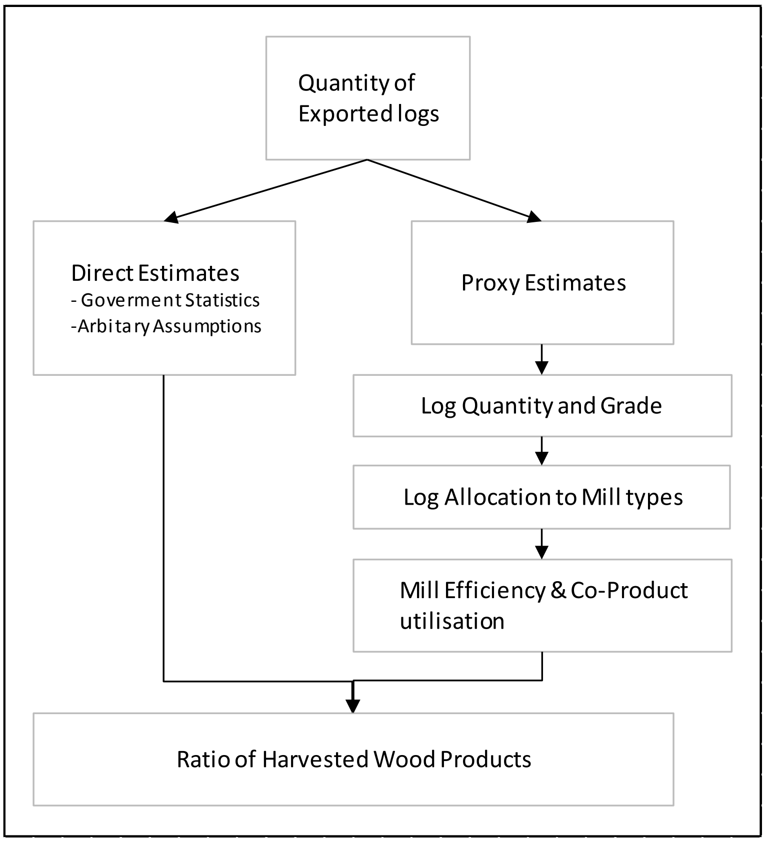

Figure 48: Methods to allocate logs to HWPs.

Direct estimates of logs to HWPs

Using a direct estimate of log allocation to products is overwhelmingly the most commonplace approach to emissions trading calculations in published studies. This approach has been applied to several countries and some of the relevant data is summarised in Table 17.

The recently completed Woodscape study (Hall et al., 2013) synthesised several disparate sources of data to categorise exported logs into product classes. They found that exported structural grade logs (0.9 Mm^3) and pruned logs (0.15 Mm^3) mostly become engineered wood products. Industrial grade lumber (5.2 Mm^3) predominantly becomes "industrial optimised engineered lumber" and the exported "appearance" logs (6.45 Mm^3) is most likely to be manufactured into plywood and veneers. Overall Hall et al. (2013) estimated that 70% of NZ radiata export logs was converted into plywood products in overseas locations.

Table 21: Percentage allocation of total wood to individual product classes

Study	Sawn Timber	Panels	Pulp	Other	Year(s)	Country
Hashimoto and Moriguchi (2004)	34	nd	8.26	57.74	1960	Japan
	47.5	nd	19.9	32.6	1970	
	42.7	nd	25.6	31.7	1980	
	37.3	nd	37.3	25.4	1990	
	30.6	nd	43.5	25.9	2000	
MEF (2009)	79.7	4.2	16	nd	1990-2000	India
Phillips and Choi (2006)	26	24	41	10	2003-2006	Korea
Chunquan et al. (2004)	79	nd	20	1	1993-2003	China
Kun et al. (2007)	38.8	34.0	18.0	9.2	2004	China
	37.8	34.0	20.1	8.1	2010	
	31.0	30.4	30.5	8.0	2020	
Chen et al. (2008)	76.7	0.1	23.1	0.1	1995-2004	Canada
Stockmann et al. (2012)	78.7	nd	6.9	14.4	1980-2009	USA

nd =not determined.

No study has collected empirical data on New Zealand radiata pine HWP production in the key log import countries, so this remains a significant source of uncertainty. Capturing this data in future through cooperation with forestry and/or statistics agencies in key markets would be ideal. Some studies have used unreferenced notional allocations of radiata wood and we have obtained estimates from log exporters and consultants. The results of this are summarised in **Table 18**. Differences may reflect real change over time but note that the two sets of estimates for 2015 do not agree on the dominant end use in each market.

The most convenient way to account for HWPs produced from exported logs would be to use HWP production statistics from the importing country, but these would need to separate production by the source of the raw material. No statistics at this level of detail have been located, and in practice may not be held even at an individual mill level. For example, radiata pine is commonly used as a core veneer in plywood with other species used as the face veneers. Engineered wood products may blend raw materials from a variety of sources.

This data could possibly be available from Japan, both because of the relatively high standard of statistics maintained and the more specialised use made of radiata pine. One source (Araya and Katsuhisa 2008) gave the "breakdown of domestic lumber shipment in 2006" by region of origin. This report suggests that direct production data for timber derived from New Zealand may be available in Japan. When combined with MAFF data for log imports from the same regions, the implied factor for converting log volume to timber volume for New Zealand logs was about 0.69 (**Table 19**).[24] However the Japanese Ministry of Agriculture, Forestry and Fisheries does not collect this data (M. Oosato *pers. comm*).

[24] This calculation assumes that log stocks at the start of the year were balanced by stocks left at the end.

Table 22: Radiata pine log consumption by product category and importing country

Country	Product category	Katz (2004)	Ford-Robertson et al. (1999)	G. Feast (TPT) *Pers. Com* (2012)*	Indufor (2012)
Japan					
	Paper	62	27	-	15
	Panels	38	11	5	80
	Sawn timber	-	49	95	5
	Waste	-	14	-	-
China					
	Paper	6.3	-	-	-
	Panels	56.3	-	20	70
	Sawn timber	37.5	-	80	30
	Waste	-	-	-	-
Korea					
	Paper	1.2	13	-	-
	Panels	3.9	8	15	40
	Sawn timber	94.9	65	85	60
	Waste	-	14	-	-
India					
	Paper	-	-	-	-
	Panels	-	-	65	20
	Sawn timber	-	-	35	80
	Waste	-	-	-	-

* indicative estimates for one large exporter.
- indicates there was no data.
All estimates are for the previous year to the date of the citation.

Table 23: Japanese lumber production by region of origin, 2006 (based on Araya and Katsuhisa 2008)

	Lumber volume (million m^3)	%	MAFF 2006 log imports (million m^3)	Implied log conversion factor
Domestic	7.15	56	11.645	0.61
Tropical Asia	0.14	1	0.2	0.70
North America	3.13	25	5.244	0.60
Russia	1.32	11	2.115	0.62
New Zealand	0.6	5	0.87	0.69
Others	0.22	2	0.268	0.82
TOTAL	12.56	100%	20.342	0.62

There is a separate Harmonised System (HS) code for radiata pine used in trade data, but not in FAO production data. Re-exported radiata pine semi-finished and finished products could therefore be captured by the trade data, and New Zealand could then account for a proportion based on New Zealand's share of radiata pine logs imported relative to Chile and Australia. This would still capture only a small proportion of the carbon in exported logs.

Proxy estimates of export logs to HWPs

In the absence of production data for HWPs produced from raw materials imported from New Zealand, assumptions must be made about the conversion of raw materials to semi-finished HWPs. Two possible approximations would be:

1. Use conversion proportions as for New Zealand;
2. Use conversion proportions assumed by each market.

The first assumption is used in the IPCC HWP model for reporting under the UNFCCC and is readily calculated from the New Zealand production data. However, it is likely that Kyoto Protocol reporting will require a higher standard of data. The end uses of exported logs differ between markets and do not match New Zealand usage.

National in-market average conversion assumptions are unlikely to be appropriate unless logs imported from New Zealand make up a high proportion of mill inputs and are processed into the same range of products in the same proportions as logs from other sources. This is not the case – for example, in Japan New Zealand logs make up only 5% of inputs to sawmills and are used mainly in the packaging sector, which accounts for only a small proportion of wood use in Japan – on average 7.5% 1990-2001 according to Soma and Arima (2004).

Ideally specific conversion information for New Zealand grown logs in each market is required:

1. The log-to-timber volume conversion of sawlogs to lumber in sawmills;
2. Log-to-plywood volume conversions of peeler logs to plywood;
3. End use of sawmill and plywood mill residues (conversion to panels and paper);
4. The log-to-chip conversion for pulp logs;
5. Wood chip to pulp or panel conversion.

Processing of pulp logs and wood chips is likely to be similar regardless of log origin, and paper and paperboard have a short life span which minimises the impact of any error introduced. However, FAOStat trade data does not identify pulp logs within the "Industrial Roundwood wir" category.

Allocating export logs to mill type

The first step of a proxy method to establish allocation of logs to HWPs is therefore to categorise export logs by grade. Previous work conducted by Scion attempted to better understand the production of different grade logs for export in order to investigate the growth of the NZ forestry industry. The study used data collected on annualised radiata production and log prices to split the production into grades. The output of this work is shown in Figure 42.

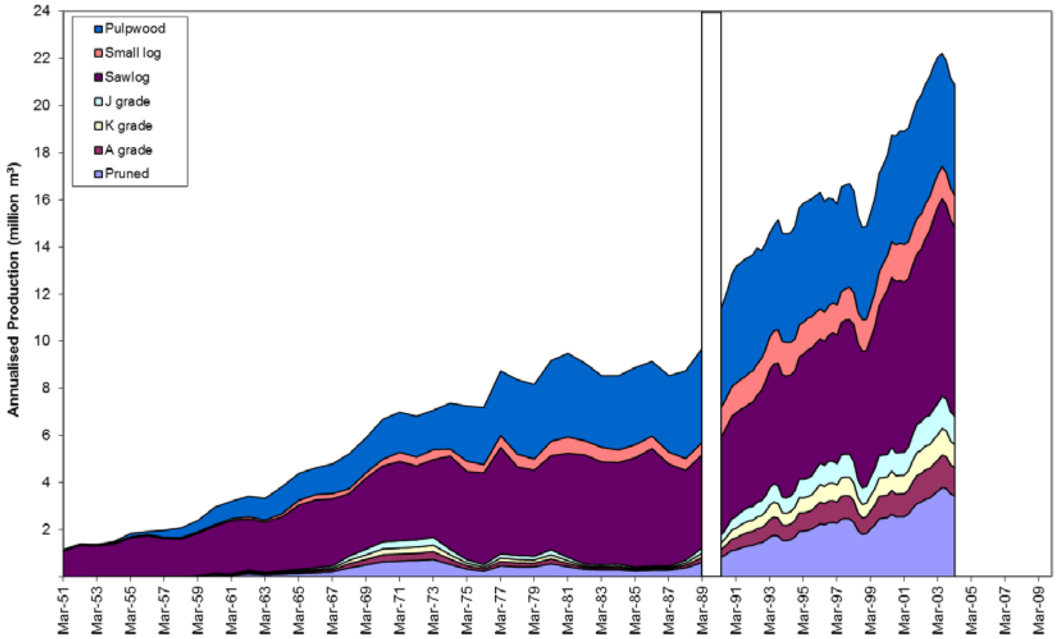

Figure 49: Estimated export log grades.

These broad grades could be used as the basis for allocating production to mill types if no other information is available, but there is no breakdown by importing country. For Japan, allocation to mill types is available from Japanese Ministry of Agriculture, Forestry and Fisheries (MAFF) and shown in Table 20.[25] Similar data has not been found for other markets.

Table 24. Imports of New Zealand logs and wood chips, JMAFF data[26]

	Sawlogs	veneer logs	chip logs	for pulp	for other	wood chip total	chip C	chip NC
1960	...	...	...	...	...			
1961	...	...	...	...	...			
1962	...	...	...	...	...			
1963	...	...	...	...	...			
1964	...	...	...	...	...			
1965	...	...	...	...	...			
1966	...	...	...	...	...			
1967	...	...	...	...	...			
1968	...	...	...	...	...			
1969	...	...	...	-	-			
1970	...	...	...	-	-			
*1971	1711	-	1	-	-			
1972	2084	-	2	-	-			
1973	1958	-	1	-	-			
1974	1367	-	5	-	-			
1975	875	-	1	-	11			
1976	1020	-	2	-	-			
1977	1100	-	3	-	-			
1978	1132	-	3	-	4			
1979	1371	-	2	-	5			

[25] Note that the 95% sawmill to 5% plywood split in 2010 matches the estimate provided by TPT in Table 18.

[26] Statistics from the Japanese Ministry of Agriculture, Forestry and Fisheries showing the input of New Zealand logs to sawmills and plywood mills, logs for chipping, and wood chips. http://www.e-stat.go.jp/SG1/estat/List.do?lid=000001061494

1980	1368	-	2	17	3			
1981	1072	-	1	-	5			
1982	877	0	0	-	3			
1983	860	-	-	-	0			
1984	819	1	0	-	0			
1985	783	0	0	-	0			
1986	733	1	1	-	0			
1987	800	6	0	-	0			
1988	859	-	-	-	0			
1989	1029	2	23	-	0			
1990	1317	103	0	-	0			
1991	1451	125	9	-	-			
1992	1464	211	14	-	-			
1993	1371	315	10	-	-			
1994	1316	277	3	…	…			
1995	1366	388	2	…	…			
1996	1307	405	0	…	…			
1997	1409	463	1	…	…			
1998	1223	382	16	…	…			
1999	1148	497	26	…	…			
2000	1250	603	21	…	…	398		
2001	1069	639	21	…	…	518		
2002	1048	576	17	…	…	400	383	17
2003	997	579	1	…	…	391	377	15
2004	943	453	-	…	…	239	228	11
2005	836	124	7			266	232	34
2006	870	83	1			253	192	61
2007	809	35	1			329	274	54
2008	833	33	0			386	310	75
2009	569	64	1			260	185	75
2010	814	44	0			357	278	79

* data before 1970 included in "Other countries" category

The JMAFF data was used as the basis to allocate export logs to Japanese mill types. For other export log markets (Korea, China, India and "other s" (mainly Taiwan and South-East Asia), estimates provided by Indufor (2012) were used. The Indufor estimates excluded export pulplogs, which may be chipped for pulp or panels, or even sawn. Table 21 gives the base mill allocation used in the model.

Table 25. Base allocation of logs to mills in export markets

	Sawmill	Plymill	Pulp mill
Japan*	95	5	0
Korea	60	39	1
China	30	69	1
India	85	15	0
Other	45	45	10

* 2010 values - time series from 1971 is used in the spreadsheet model

Mill conversion

Once export log volumes have been allocated to mills, a mill conversion efficiency rate is required to convert the log input to product outturn. Conversion rates are driven by technology, markets and the nature of the resource being processed and therefore vary over time. Enters (2001) reported recovery rates ranging from 42 to 60 per cent (average 50) for sawmills in Asia and 43 to 50 per cent (average 46) for plywood mills. While these were not mills specialising in processing radiata pine, there is some degree of consistency between studies and the data for the New Zealand's key markets do not exhibit substantial difference from the UNECE (2010) survey of European countries, Canada and the USA (**Table 22**).

Table 26: Mill conversion rates

	Product	Hashimoto and Moriguchi (2004)	Chunquan et al. (2004)	Gundimeda (2001)	UNECE (2010)#
Region		Japan	China	India	Europe/Nth America
Solid wood					
	All solid wood products	0.54			
	Lumber		0.55*		0.54
	Lumber, sleepers and Panels			0.5	
	Veneer		0.52$		0.49
	Particleboard		0.71+		0.82
	Fibreboard		0.56+		0.85
	Plywood				0.50
Pulp and Paper					
	Paper	0.97		0.85	
	Chips (used for Pulp)		0.87-		
	Pulp and paper				0.95

Chunquan et al. (2004) cite:
*Forests Forgone – Book by Friends of the Earth,
+ ECE/TIM/BULL/50/3 — bulletin 50/3 published by FAO/United Nations Economic Commission for Europe,
$ annual reviews by the International Tropical Timber Organization, - URS pers comm.
# mean of UNECE regions and manufacturers

The base mill conversion rates assumed in the spreadsheet model are given in Table 23. The panel mill conversion includes the use of plymill residues in other panel products. Log to paper conversion is based on 2% loss of fines with chipping, 70% recovery in the conversion of chips to pulp (assuming a mix of mechanical and chemical pulping) and 4% loss and waste in paper production.

Table 27. Assumed mill conversion factors (HWP output per log input)

	Sawmill	Panel mill*	Paper mill
Japan*	0.60	0.55 + 0.15	0.66
Korea	0.55	0.55 + 0.15	0.66
China	0.55	0.55 + 0.15	0.66
India	0.50	0.50 + 0.10	0.66
Other	0.50	0.50 + 0.15	0.66

* plymill conversion + residues to other panel mill

Residue use

Mill conversion rates describe the conversion of logs to the primary product, but residues generated in sawmill and plymills may also be chipped for conversion into panel products or paper. Again, there are no specific data for radiata pine processing in key markets, and conservative assumptions could be used, such as assuming that all residues are converted to paper, or incinerated and therefore instantly emitted in the model. Hashimoto and Moriguchi

(2004) estimated that 73% of carbon in logs was converted to products (about half solid wood and half paper) while 18% was used as fuel. The remaining 9% was waste. Kayo and Amano (2004) reported that only 7% of sawmill residues were incinerated in Japan. However, not all recycling of waste is used in HWPs that meet Kyoto accounting criteria.

The base assumptions for residue use are listed in table x. For example, sawmill recovery as sawn wood in Japan is assumed to be 60% (Table 24), with an additional 10% ultimately incorporated within each of panels and paper. In total 80% of input to Japanese sawmills is assumed to be incorporated within HWPs. These assumptions can be changed for each year and major market. Note that the residue allocation percentages in Table 24 are net of any further processing losses, so 10% of log input to Japanese sawmills is converted to paper after losses from chipping, pulping and papermaking are taken into account.

Table 28. Assumed residue use (allocation to secondary HWP as % of input to primary mill)

	Sawmill to panels	Sawmill to paper	Plymill to panels	Plymill to paper
Japan	0.10	0.10	0.15	0.10
Korea	0.15	0.10	0.15	0.10
China	0.15	0.10	0.15	0.10
India	0.10	0	0.10	0
Other	0.15	0.15	0.15	0.10

Appendix VII – New Zealand specific data for backfilling to 1900

PRODUCTION 1900-1960

Industrial roundwood production from New Zealand forests was not generally reported in the early 20th century. Annual estimates are available from 1951 in MPI data, and earlier estimates are available from Rhodes and Novis (2002)[27] and at five yearly intervals from 1921 (Levack 1979)[28]. The five-yearly interval estimates were scaled according to available sawn timber estimates. From 1900 to 1920, production of roundwood was set at twice the production of sawn timber.

Production of sawn timber was reported in the New Zealand Year Book for 1916 and annually from 1918. Data was converted from board feet using a factor of 0.00236 where necessary. A range of year-end conventions was used and no attempt was made to convert data to calendar years – the estimates should be seen as indicative. A breakdown by the main species (kauri, kahikatea, rimu, matai, totara, beech, radiata and others)[29] was also published and this was retained to allow a weighted-average wood density to be calculated. These Year Book estimates were used until 1951 when sawn timber production by species was available from MPI data.

For the period from 1900 to 1915, data was based on estimates of kauri sawn timber production in 1900 and 1904 provided by Thode (1983)[30], the relative production of different species from 1916-1920, and the knowledge that kauri (and total) production peaked around 1907. These estimates are indicative only, but certainly better that those produced using the default U variable approach. They have little impact on UNFCCC reporting due to the decay rate assumed, and no impact on Kyoto Protocol reporting.

Panel production is available from 1946 for plywood and fibreboard. Plywood production before 1946 was set at 10% of sawn wood production, which was the average for the 1946-1951 period. Peeler log production by species was available from 1971 but the weighted average density was similar to that calculated for sawn timber so the value derived for sawn timber was used. Particleboard was invented in Germany during the Second World War and was set to zero until 1959 when MPI data provided small volumes. An FAO commodity report on fibreboard stated that "*New Zealand has but one plant which up to this time produced only insulating board. Equipment for the manufacturing of hardboard has now been installed and is expected to be in operation in 1948*." Capacity was expected to increase from 11,000 to 20,000 tonnes (FAO 1948)[31]. The production of insulating board was set at zero before 1920 then increased linearly to the FAOSTAT data point in 1961. MDF was not produced until 1976.

The first paper mills in New Zealand were in operation by 1900 but production was largely based on rags, old rope and other fibres as well as imported pulp. Wood-based pulp became more important in the 1940s with the development of the Whakatane board mill and much

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27 Rhodes, D., Novis, J., 2002. The Impact of Incentives on the Development of Plantation Forest Resources in New Zealand. MAF Information Paper vol. 45. Ministry of Agriculture and Forestry, Wellington. 61 pp.

28 Levack, H. H. (1979). Future national wood supply. New Zealand Journal of Forestry, 24, 159-171

29 In many years the "other species" category was further broken down in up to 20 individual species.

30 Thode, P.J. 1983 Northland's forest history and present resources. New Zealand Journal of Forestry 28(2) 203-224

31 FAO 1948. Fibreboard. Unasylva 2(4).

more so in the 1950s with construction of pulp mills at Kinleith and Kawerau. Given the short half-life assumed for paper, the production of paper and paperboard was simply set at 2% of sawn timber production from 1900 until 1940 when the MPI time series began. Comparisons of backfilling based on New Zealand estimates and the default approach using the U variable are shown in Figure 43-Figure 45.

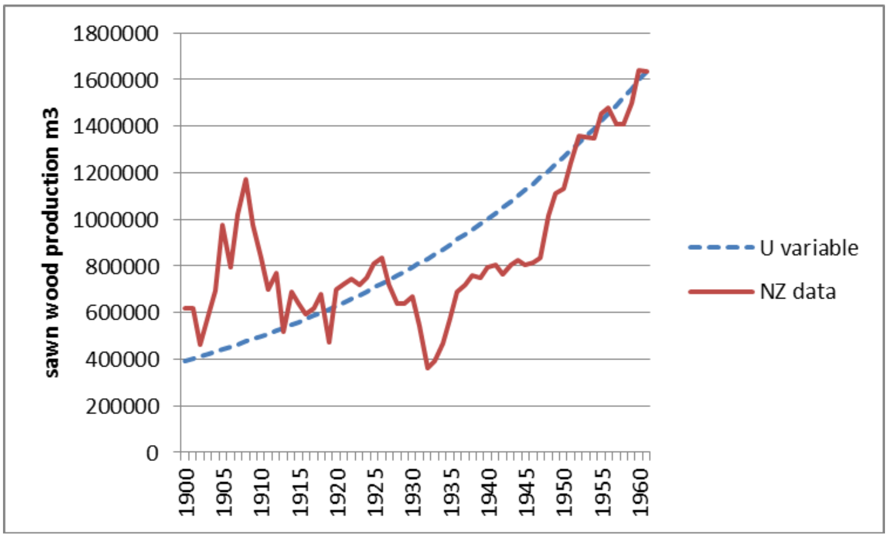

Figure 50. Backfilling sawn wood production data – U variable versus NZ data.

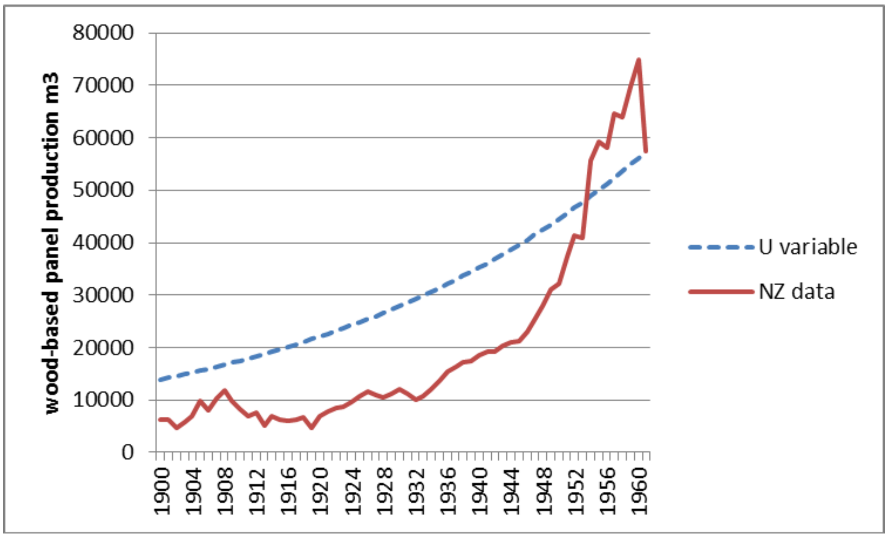

Figure 51. Backfilling panel production data – U variable versus NZ data.

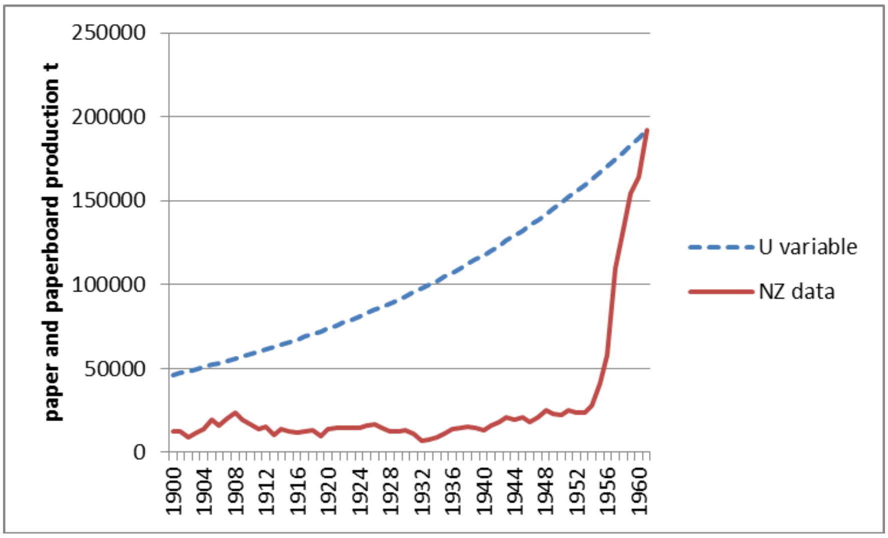

Figure 52. Backfilling paper production data – U variable versus NZ data.

IMPORTS 1900-1960

Imports data is available in the New Zealand Year Books from 1900 but not always in a useful format. Imports in 1900 are given in Table 29 as an example – note in particular that logs, palings, posts and rails are all given as number of items, rather than a measured quantity. The list also includes finished HWPs.

Table 29. HWP Imports in 1900.

Paper— Bags, coarse	16 cwt.
Bags, other kinds ..	2,275 cwt.
Butter-paper	2,587 cwt.
Paperhangings ..	985,496 pieces
Printing	120,609 cwt.
Wrapping	3,841 cwt.
Writing	9,700 cwt.
Unenumerated ..	1,628 cwt.
Laths and shingles ..	682,000 sup. ft.
Logs	1,836 No.
Logs, hewn	3,461,106 sup. ft.
Palings	472,741 No.
Posts	12,628 No.
Rails	1,350 No.
Sawn, undressed ..	7,245,208 sup. ft.
Sawn, dressed	139,720 sup. ft.
Unenumerated ..	..

Sawn timber data was obtained annually from 1924, with some estimates obtained for individual years before that. It was not always possible to distinguish between logs, poles, sleepers and sawn timber. MPI data on sawn timber imports by species from 1971 showed an even split between hardwoods and softwoods. The main softwoods were Douglas fir, western red cedar and redwood, with an estimated average weighted density of about 400 kg/m^3. The main hardwoods were Eucalyptus, oak and tropical hardwoods, with an estimated weighted average density of about 700 kg/m^3. A constant weighted density of 550 kg/m^3 was assumed. These same species were also prominent in the pre-1971 data.

No information was obtained on fibreboard imports before 1955 or other panels before 1961, so linear interpolation was used to fill the time series, assuming 0 in 1920 for fibreboard and in 1900 for veneer and plywood. Approximate values for paper and paperboard were estimated for 1900 and 1904, with linear interpolation used to fill the time series until annual data was available from 1950. Pulp imports were assumed to increase linearly from zero in 1900 to the first data point available in 1955.

EXPORTS 1900-1960

Export data for sawn timber were available annually in the New Zealand Year Books from 1900. Some information on the proportion by species was also available, but for simplicity it can be assumed that exports were the same mix of species as production. Australia was by far the main export market for sawn timber before 1961, as it has remained.

Exports of other products did not begin until much later. Exports of pulp and paper and paper began in 1954 with paper (mainly newsprint) exports increasing rapidly. The Japanese export log market began in 1958 while the Japanese wood chip export market began in 1970.

A comparison of estimates of export data for 1900-1960 based on the IPCC U variable and use of New Zealand data is given in Figure 46-Figure 48.

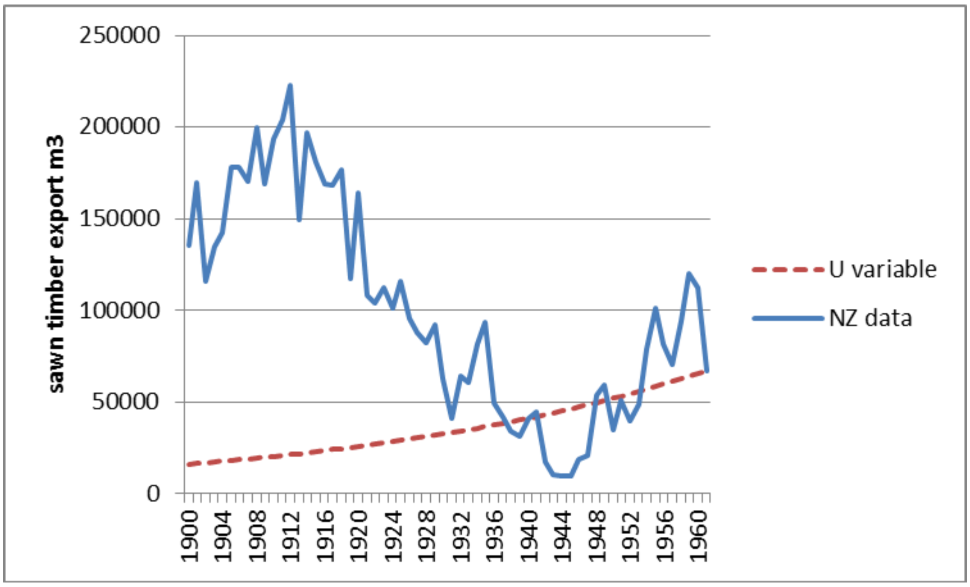

Figure 53. Backfilling sawn wood export data – U variable versus NZ data.

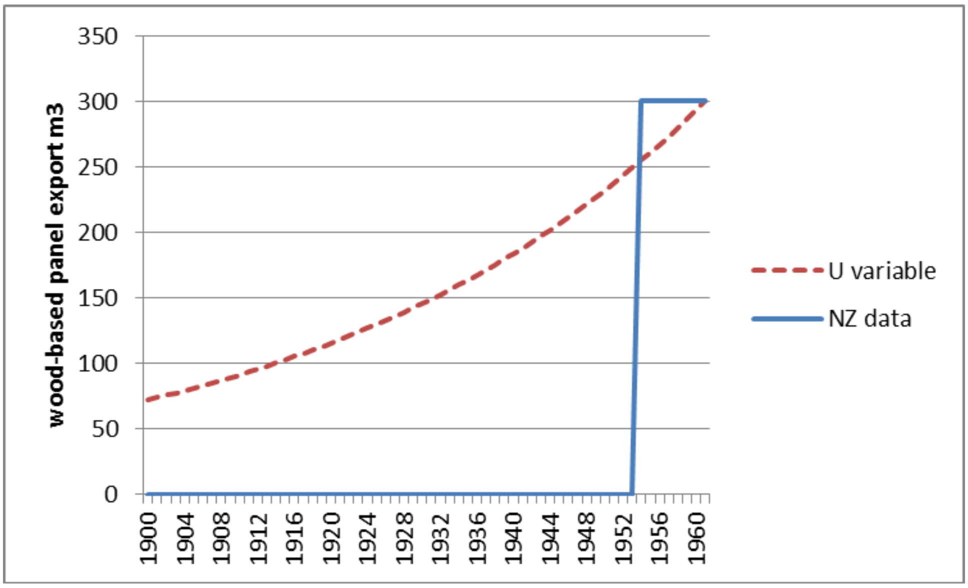

Figure 54. Backfilling panel export data – U variable versus NZ data.

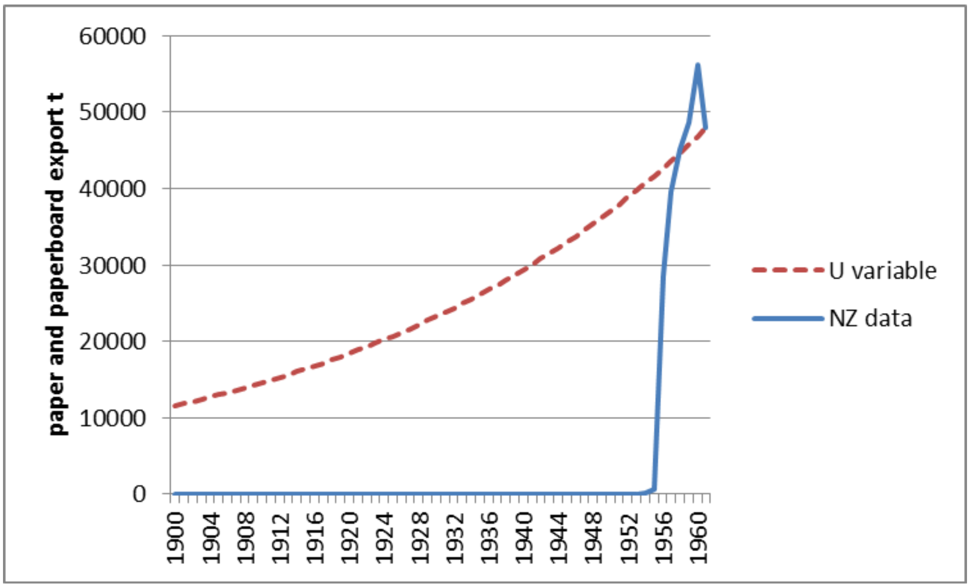

Figure 55. Backfilling paper export data – U variable versus NZ data.

Data backfilling is only required for UNFCCC reporting. Clearly the default U variable approach does not provide a very good estimate of New Zealand's actual HWP production and trade, even allowing for the broad assumptions made in compiling the New Zealand data set. However, in practice the differences are minimised because by 1990 the assumed decay rate has greatly reduced the contribution from inherited emissions.