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Manatū Ahu Matua

Material flow and end-use of harvested wood products produced from New Zealand log exports

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Table of Contents

Executive Summary	1
Acknowledgements	4
Introduction	5
Material flow and end use – China	7
Material flow and end use – South Korea	38
Material flow and end use – India	54
Reference	71

Executive Summary

In 2014 MPI commissioned a project to develop a robust methodology and models that support New Zealand to meet UNFCCC and Kyoto Protocol (KP) requirements for tracking the volume and type of wood products produced from New Zealand grown roundwood in overseas markets. The objective was to enable MPI to make informed decisions around the options concerning the uptake and policy regarding HWP in national level greenhouse gas (GHG) reporting and accounting, the Emissions Trading Scheme (ETS), and policy development processes.

The purpose of this report is to review material flows and end-uses of harvested wood products produced from New Zealand log exports. The focus is on New Zealand's three major markets:

- China (68% of 2015 log exports)
- South Korea (17%)
- India (11%)

The approach taken has included:

- A survey of New Zealand log exporters. Information was obtained about the grades that they exported, the probable products produced from the exported logs and their likely end-use.
- Visits to each of the three countries. Visits were made to wood processing plants, wood product manufacturers, construction sites, ports, logyards, log traders, industry associations, researchers and government officials. These visits provided an overview of the material flow and end uses of the products produced from New Zealand export logs.
- Development of estimates. On our visits we asked a wide range of people the same questions. Subsequently we have distilled the responses in order to converge on a consensus view.

Main findings are:

China

In 2015 China imported 10.5 million m^3 of logs from New Zealand including 9.9 million m^3 of radiata pine, 0.5 million m^3 of Douglas fir and 0.1 million m^3 of minor species We estimate that 68% of the volume was sawn and 32% peeled to produce overall:

- 24% construction lumber
- 9% appearance lumber
- 11% packaging lumber
- 16% slabwood
- 8% sawdust
- 23% construction plywood
- 1% appearance plywood
- 3% packaging plywood
- 5% plymill residues

The most important use of New Zealand logs in China is the production of lumber and plywood for temporary construction. Although some of this is recycled into low grade panel products some is burnt after use. Consequently the weighted average half-life[1] is only 6.6 years with an indicative potential range of 5.5 years to 7.9 years (or 4.4 to 9.5 years if IPCC default half-lives are also varied).

Harvested wood products that contribute materially to the average half-life of 6.6 years are:

- appearance lumber.
- the use of plymill residues, sawmill slabwood and sawdust to produce panel products (MDF and Particleboard).
- panels recycled from construction lumber and plywood.
- packaging lumber.

South Korea

In 2015 South Korea imported 2.6 million m^3 of radiata pine logs from New Zealand. We estimate that 77% of the export log volume was sawn, 21% was peeled and 2% was sent directly to an MDF plant. The products produced were:

- 33% construction lumber
- 1% appearance lumber
- 14% packaging lumber
- 22% slabwood (or MDF log)
- 9% sawdust
- 9% construction plywood
- 4% appearance plywood
- 8% plymill residues

A large proportion (64%) of radiata pine ends up as MDF (30%) through the use of sawmill and plymill residues or as particleboard (34%) from the recycling of construction lumber and plywood. The weighted average half-life is 18.0 years with an indicative potential range of 14.8 years to 21.3 years (or 11.9 to 25.4 years if IPCC default half-lives are also varied).

The average half-life of 18.0 years depends heavily on:

- particleboard recycled from construction lumber and plywood.
- MDF produced from logs, sawmill slabwood and plymill residues.

A critical assumption is that these panel products have the IPCC default half-life for panel products of 25 years.

[1] Half-life refers to the time taken for half of the carbon contained in wood products to be emitted. In contrast, average lifetime is the time, on average, during which a specific product is in use. In the case of an exponential decay function the half-life equals 0.693 of the average lifetime.

India

In 2015 New Zealand exported 1.6 million m^3 of radiata pine logs to India. All logs were unpruned and we estimate that they were sawn to produce:

- 28% construction lumber
- 32% packaging lumber
- 13% blockboard
- 14% slabwood
- 14% sawdust

The construction lumber is used almost exclusively as battens to hold plywood in place for concrete formwork. It is mainly burnt after use with little recycling. All slabwood and most sawdust are also used for fuel. The weighted average half-life is 2.5 years with an indicative potential range of 1.2 years to 4.6 years (or 0.7 to 8.5 years if half-lives are also varied).

Harvested wood products that contribute materially to the average half-life of 2.5 years are

- blockboard.
- sawdust used for particleboard.
- export packaging lumber.

Additional work

Additional work is required to improve these estimates which are indicative only.

China.

Better information is needed on:

- End products produced from each log grade; e.g. the products produced from appearance lumber.
- Conversion factors from a wider range of sawmills and plymills.
- The proportion of slabwood chips and plymill residues used for paper, particleboard, MDF and fuel.
- The proportion of construction lumber and plywood that is recycled and the longevity of the panels produced.
- What happens to packaging material after use.

South Korea.

Further work is required to confirm:

- The split between construction lumber and packaging.
- The life cycle of packaging.
- That the majority of lumber and plywood used for formwork is recycled and used for particleboard.
- That the default IPCC half-life of 25 years is appropriate for this product.

India.

Questions remain about:

- The split between construction lumber and packaging.
- The proportion of packaging lumber used for exports. Export packaging has a longer life than domestic packaging.
- The split of sawmill residues between slabwood and sawdust.
- The proportions of sawdust used for particleboard and fuel.
- The life of blockboard and packaging.
- The need to confirm that little construction lumber gets recycled.

Further work will also be required to update the estimates as end-use changes over time.

Acknowledgement

We acknowledge the support of Rayonier|Matariki Forests for allowing us to accompany marketing staff on visits to each of the main markets. We greatly appreciate the generosity of time and the patience extended to us by Chris Rayes and his team: Luan Fei and Liam Liu (China), Moon Song (South Korea), Sasha Barbin and Raj Kapadia (India).

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Introduction

New Zealand is required to report on the GHG emissions and removals from the forestry sector to satisfy a range of commitments under the UNFCCC and KP. Alignment between the national GHG inventory reporting and the ETS is an important mechanism to promote relatively low cost GHG abatement processes. International reporting is required on HWP from the 2013 reporting year (i.e. the 2015 submission) onwards under the convention and the KP. The change in GHG emissions that arises from a HWP adjustment will impact on forestry forecasts and projections. Forecasts beyond CP2 are becoming increasingly relevant, as global agreements to succeed the existing arrangements are currently being negotiated. The NZ Government is actively working on analysing the effects of any national commitment on a new global agreement. The longer term forecasts reported by MPI underpin New Zealand's position in these negotiations.

Consequently MPI commissioned a project to develop a robust methodology and models that support New Zealand to meet UNFCCC and KP requirements for tracking the volume and type of wood products produced from NZ grown roundwood in overseas markets. Constraints and data limitations need to be fully described and critically evaluated. The results will enable MPI to make informed decisions around the options concerning the uptake and policy regarding HWP in national level GHG reporting and accounting, the ETS, and policy development processes.

The purpose of this report is to review material flows and end-uses of harvested wood products produced from New Zealand log exports. The focus is on New Zealand's three major markets:

- China (68% of 2015 log exports)
- South Korea (17%)
- India (11%)

New Zealand log exporters were visited in late 2014/early 2015 and information was obtained about the grades that they exported. Detailed information was provided on the volumes exported to each port. Those surveyed were also asked to estimate the products produced from the exported logs and their likely end-use. Further information was sought on the major customers they supply and the customer's position (e.g. whether they were a trader or manufacturer) in the value chain.

In 2015 we went to the three major log export markets and visited wood processing plants, wood product manufacturers, construction sites, ports, logyards, log traders, industry associations, researchers and government officials. These visits provided an overview of the material flow and end uses of the products produced from New Zealand export logs.

This information has been used to answer 5 key questions related to harvested wood products in each country:

- What products get produced from each log grade?
- What is the conversion from log to product?
- What happens to mill residues?
- What happens to construction site material after use?
- What happens to packaging material after use?

This report provides a summary for each country. Estimates are provided for the average half-life of the products produced in each country from logs exported in 2015. These estimates are indicative only. The further work required to improve the estimates is summarised at the end of the section on each country.

In some cases the estimates are assumptions. For example, the half-life of packaging material is a major unknown in this work. A specific study is required to determine the likely life of specific packaging items – pallets, cable drums, and dunnage material.

The estimates contained in this paper are "point in time" only. As such they represent the economic conditions in 2015 in China, India and Korea, and strictly only apply when the relative requirements of the different end uses are the same as 2015. That is, in 2015 in each of these countries, the construction, packaging and furniture and joinery end-use activities were at a certain level, determined by the amount of residential and non-residential building activity, the amount of activity in those industries requiring packaging, and the domestic and export demand for furniture, joinery and components for these industries. As the relative requirements of each of these major end-uses changes, the relative weightings of the half-lives of each end use will change also.

In order to quantify these impacts it would be important to gather estimates of usage at different points in the economic cycle. This would help to understand the nature of the relationship between end use activity and the use of wood. For example if construction activity doubled and packaging and appearance grade timber requirements stayed the same, how would that affect demand for sawn timber in each end use? We would also need to have reliable data on levels of end-use activity for the major end-uses of New Zealand radiata pine.

Over the longer term, substitution between competing products, and competition between domestic and export production will also have an impact on half-lives. We did not specifically study substitution trends in this research. However, for example, the use of plywood and sawn timber for formwork has largely been replaced in developed markets by the use of steel shuttering. This has a higher capital cost but much lower labour cost. Whether the same trends will occur in our developing country markets is not known.

1. Material flow and end use – China

Background

Three different regions are recognised for the import of New Zealand logs to China (Figure 1.1):

- North (includes Shandong province and the region around Beijing).
- East (includes Shanghai and the Yangtze delta).
- South (includes Fujian province and the Pearl River delta).

Figure 1.1: Map of China showing 3 main regions through which New Zealand logs are imported.

Although logs are exported to many ports (Table 1.1) there are dominant ports:

- Lanshan and nearby Lanqiao in Shandong province (North).
- Changshu and Shanghai in the East.
- Zhangzhou in the South.

Table 1.1: Ports in each Chinese region through which New Zealand logs are imported

North	***East***	***South***
Tianjin	Shanghai	Putian
Jintang	Changshu	Xiuyu
Caofeidian	Taicang	Zhangzhou
Penglai	Luojing	Mawan
Longkou	Yangzhou	Yantian
Dongjiakou		Shatian
Qingdao		Shenzhen
Lanqiao		Nanwei
Lanshan		Qinzhou
Lianyungang		Fangcheng

In 2015 visits were made to all three regions:

- Shandong/Lianyungang/Lanshan/Linyi/Beijing in the North.
- Shanghai/Taicang/Yangtze Delta in the East.
- Shenzhen/Zhangzhou/Xiuyu in the South.

Information was obtained from visits to wood processing plants, wood product manufacturers, construction sites, ports, logyards, log traders, industry associations, researchers, and the State Forestry Administration.

Main findings

In 2015 China imported 10.5 million m^3 of logs from New Zealand including 9.9 million m^3 of radiata pine, 0.5 million m^3 of Douglas fir and 0.1 million m^3 of minor species (including Corsican pine, poplar and eucalypt). The 2015 volume represents a reduction from the 11.9 million m^3 imported in 2013 (Figure 1.2). China imports a full range of log grades (Table 1.2).

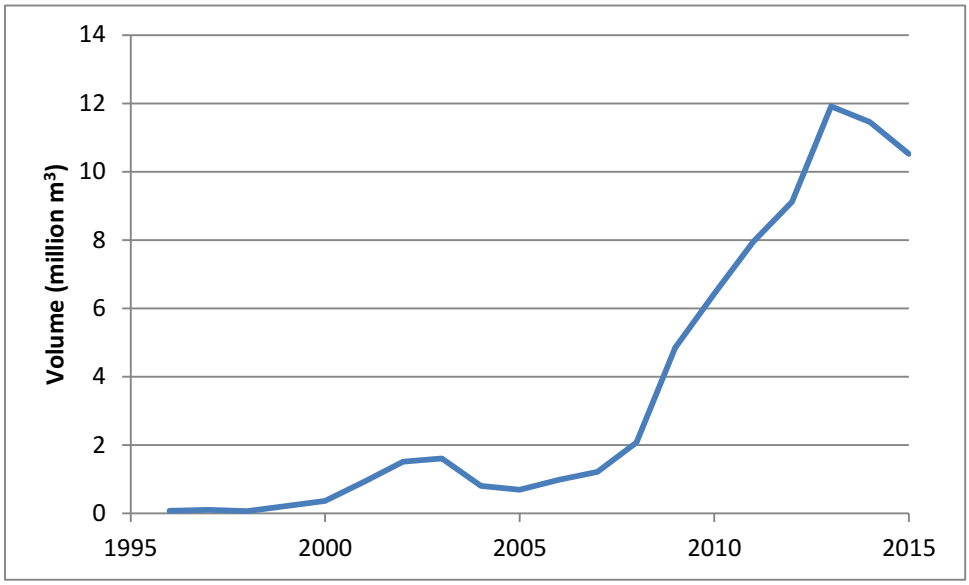

Figure 1.2: Volume of logs exported from New Zealand to China. Source MPI.

Table 1.2: Indicative specifications of radiata pine export log grades with percentage of 2015 log exports to China.

	Min small end diameter (cm)	Max branch size (cm)	% of 2015 volume
P	30 (or 34 or 40)	0	8
AO	40	10	7
A	30	10	39
K	20	10	24
KM	16	7	3
KI	30	20	9
KIS	10	no limit	9

What products get produced from each log grade?

A detailed allocation of logs to different processes is given later. General patterns are:

- Pruned logs (and partially pruned logs) are primarily processed into furniture.
- AO logs are processed into:
    - furniture and also edge-glued panels used for furniture and doors.
    - construction lumber.
- A and K logs are primarily processed into construction lumber or plywood:
    - These grades also provide packaging lumber.
    - A logs are also processed into appearance lumber.
- KM logs are processed into:
    - Construction and packaging lumber (North and East).
    - Plywood (South).
- KI and KIS logs are primarily processed into plywood.
- Douglas fir logs are primarily processed into construction timber.

Chinese sawmills typically have saw sets consisting of two vertical bandsaws, a primary breakdown saw (Figure 1.3) followed by a secondary breakdown saw (Figure 1.4). Some mills have a multi-ripsaw as the secondary saw (Figure 1.5). Larger pieces of slabwood are often cut into small packaging lumber (Figure 1.6). A saw set cuts about 50 m^3 of logs per day.

Figure 1.3: Typical primary breakdown saw (vertical band saw)

Figure 1.4: Typical secondary breakdown saw (vertical band saw)

Figure 1.5: Secondary breakdown (multi-ripsaw)

Figure 1.6: Resawing slabwood into small packaging lumber

Until 2015 there has been an increasing demand for pruned logs (and also some AO and A grade logs) for appearance products. Flitches (Figure 1.7) and lumber produced are defected (Figure 1.8) and a range of products are produced including edge-glued panels (Figures 1.9 and 1.10), mouldings (Figure 1.11), baby cots (Figure 1.12), and furniture (Figure 1.13).

Figure 1.7: Flitches sawn from a pruned log

Figure 1.8: Defecting operation

Figure 1.9: Clear edge-glued panels

Figure 1.10: Knotty edge-glued panels

Figure 1.11: Finger-jointed radiata pine mouldings

Figure 1.12: Clear top rails for baby cots

Figure 1.13: Traditional Chinese furniture, radiata pine

The mainstay for the demand of radiata pine in China has been temporary construction, both lumber (Figure 1.14) and also plywood (Figures 1.15 to 1.17). This is used for concrete formwork (Figures 1.18 to 1.20).

Figure 1.14: Construction lumber

Figure 1.15: Spindle-less veneer lathe

Figure 1.16: Veneer sheet production

Figure 1.17: Veneer drying

Figure 1.18: Shanghai construction site

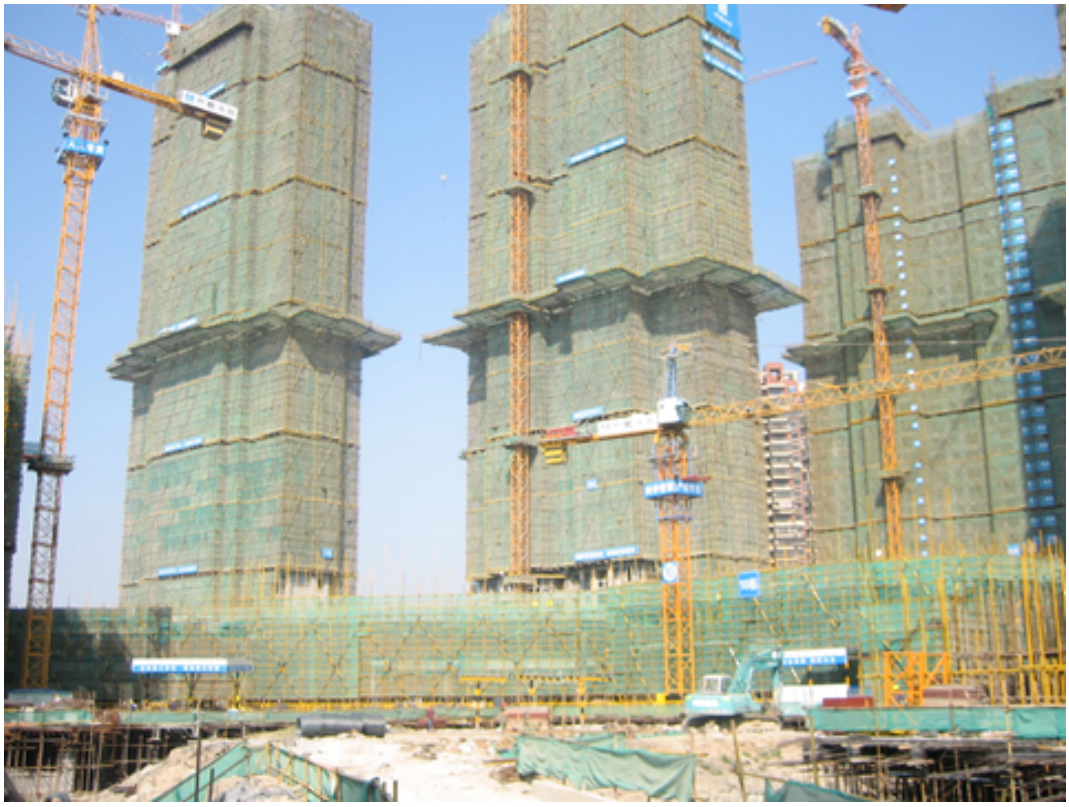

Figure 1.19: Construction site in Zhangzhou

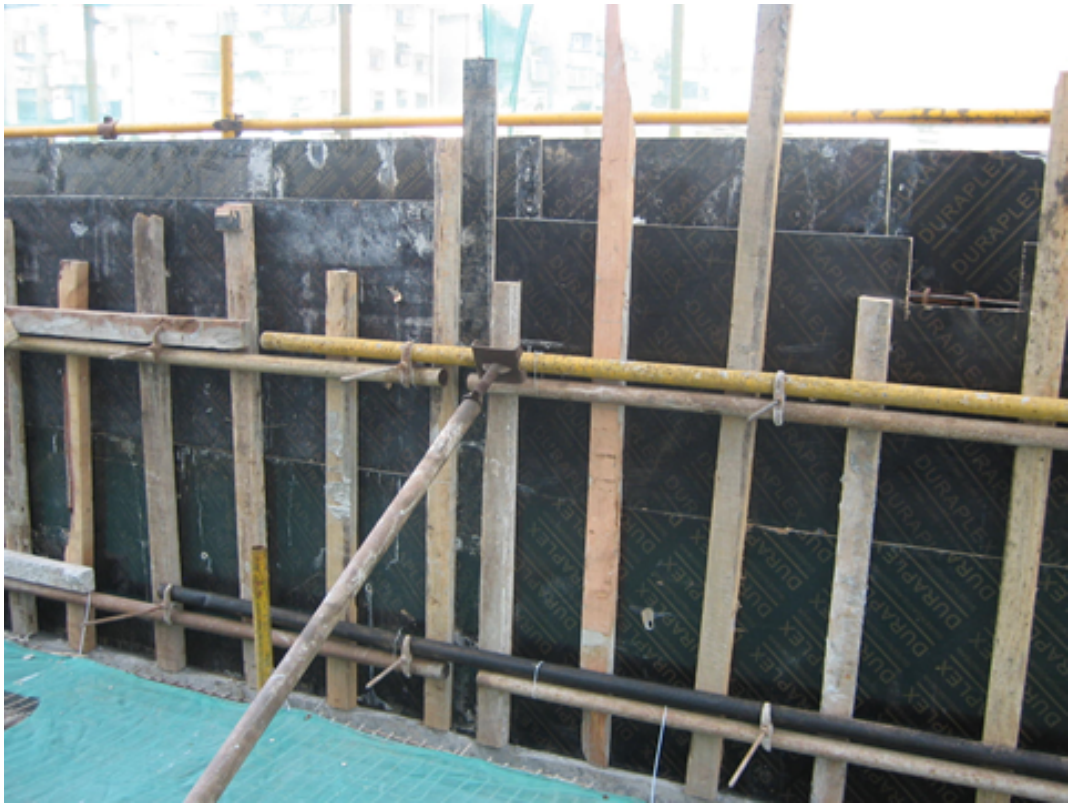

Figure 1.20: Use of construction plywood and lumber

What is the conversion from log to product?

- Sawmill primary conversion (6 mills) varies from 50 to 73% with:
  - 6 to 10% sawdust.
  - 20 to 30% slabwood.
- Some mills (including the 3 sawmills that we saw in the South) get an additional 7 to 10% conversion by sawing the larger pieces of slabwood to produce small packaging lumber.
- Veneer primary conversion (3 mills) was:
  - 70 to 80% to veneer/plywood.
  - 5 to 10% cores (Used as mop handles or frames).
  - 10 to 20% waste strip.
- The majority (>90%) of the plywood produced was for temporary construction. The remainder is mainly used for packaging; e.g. for packaging export products.

What happens to mill residues?

- Slabwood is chipped with:
    - the majority of chips produced in the East going to pulpmills.
    - unknown proportions of the chip produced in the North and South going to:
        - pulpmills.
        - particleboard plants.
        - MDF plants.
    - Very little slabwood is burnt for fuel.
- Sawdust is used for:
    - Fuel/pellets/incense/charcoal.
    - Particleboard.
- Veneer cores are used as mop handles or photo frames.
- Veneer roundup ribbon goes to:
    - Pulpmills.
    - particleboard plants.
    - MDF plants.

Figure 1.21: Slabwood being chipped near Taicang

Figure 1.22: Chips being loaded onto a barge near Taicang for shipping up the Yangtze River to a pulpmill at Huaihua, Hunan

Figure 1.23: Chips being loaded onto a truck near Shenzhen for cartage to pulpmills 800km away in Hunan and Fujian

Figure 1.24: Sawmill slabwood at an MDF plant in Lanshan

Figure 1.25: Veneer strips and plywood offcuts at a particleboard plant in Linyi

Figure 1.26: Pellets made from sawdust near Taicang

What happens to construction site material after use?

- Construction lumber and plywood is used repeatedly on the construction site until it is no longer fit for purpose. Construction lumber is used about 2 to 7 times over a 3 month period while construction plywood is used 4 to 8 times over a 2 to 3 month period.
- Unknown proportions are:
    - recycled into panel products of varying, but generally low, quality.
    - Burnt.
- Initial impressions are that a substantial proportion of the construction timber and plyform is recycled with the waste (ie very small pieces, delaminated plywood) burnt.

What happens to packaging material after use?

- We do not know.

Figure 1.27: Construction site waste, Shanghai

Figure 1.28: Used construction ply awaiting recycling at roadside in Linyi

Figure 1.29: Removal of nails from used construction ply, Linyi

Figure 1.30: Used construction ply in recycled panel product

Figure 1.31: New surface veneer put on recycled construction ply

Figure 1.32: Used construction lumber ripped into small pieces

Figure 1.33: Ripped ex-construction lumber is used as core for recycled panel product

Figure 1.34: New surface veneer put on recycled construction lumber

Figure 1.35: Panels made from recycled construction ply about to be used for temporary walkway floor at a construction site in Zhangzhou

Figure 1.36: Old pallets used for boiler fuel

Figure 1.37: Construction ply and lumber used as boiler fuel

Figure 1.38: Construction ply used as boiler fuel

China HWP Model

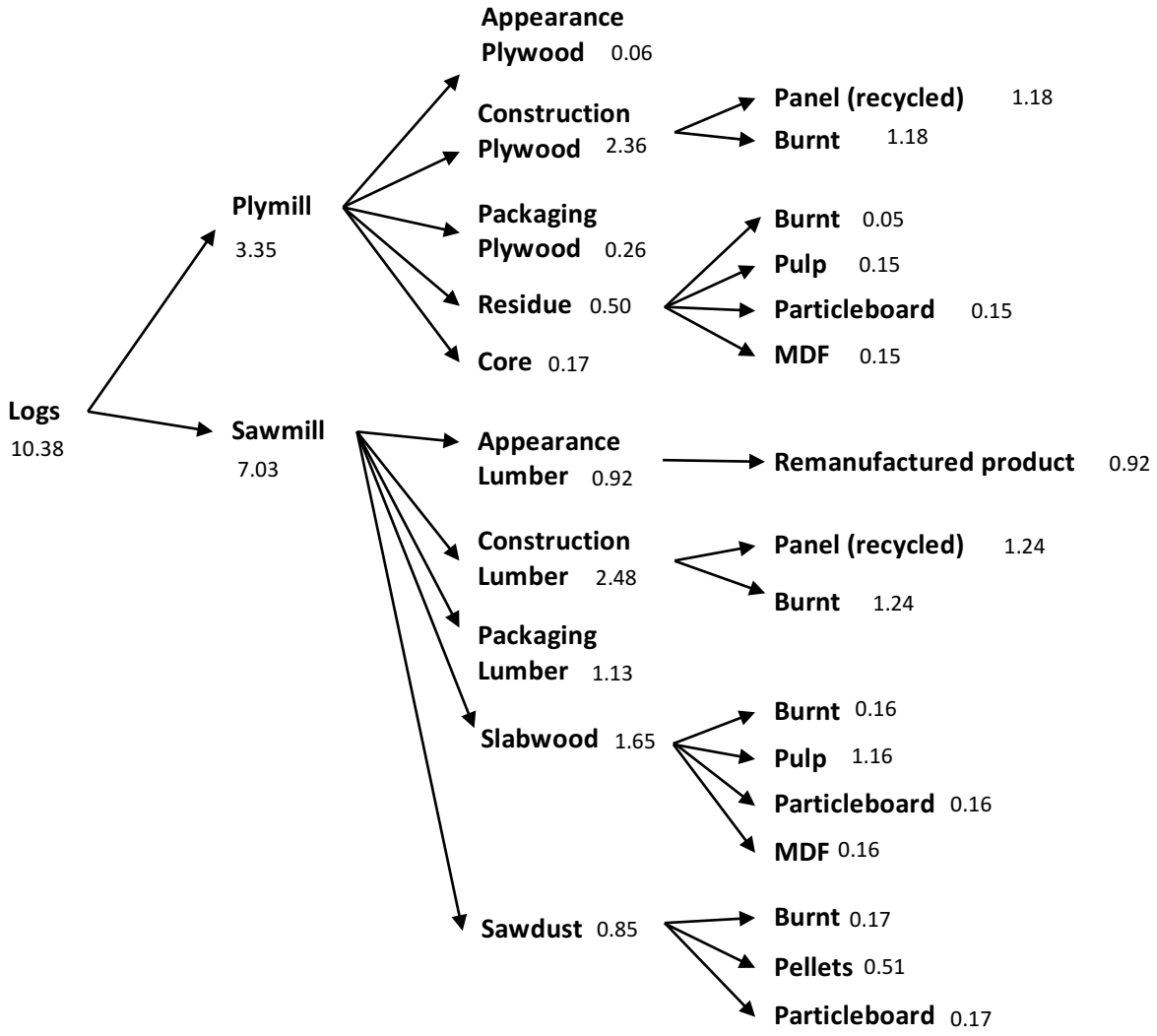

Figure 1.39: Outline of material flow with volume estimates (in million m^3 roundwood equivalent) for 2015 for radiata pine and Douglas fir. Volume estimates are indicative only.

Inputs to the model

1. Log grade mix

This information came from New Zealand log exporters

2. End Use percentages

Information came from New Zealand log exporters. It was assumed that 100% of Douglas fir was sawn for construction lumber.

Table 1.3: Log grade mix and end-use percentages for radiata pine exported from New Zealand to North China in 2015.

End Use Percentages (%)							Total	Grade Mix
		Plywood	Appearance Lumber	Construction Lumber	Packaging Lumber	Reconstituted		
North	**P**	5%	95%				100%	5%
China	**AO**		20%	80%			100%	7%
	A	20%	50%	25%	5%		100%	44%
	K			80%	20%		100%	27%
	KM			40%	60%		100%	3%
	KI	90%		5%	5%		100%	9%
	KIS	90%			5%	5%	100%	5%
Total								100%

Table 1.4: Log grade mix and end-use percentages for radiata pine exported from New Zealand to East China in 2015.

End Use Percentages (%)							Total	Grade Mix
		Plywood	Appearance Lumber	Construction Lumber	Packaging Lumber	Reconstituted		
East	**P**	10%	90%				100%	16%
China	**AO**		80%	20%			100%	11%
	A	20%	5%	70%	5%		100%	35%
	K	10%		60%	30%		100%	20%
	KM			40%	60%		100%	3%
	KI	80%		10%	10%		100%	6%
	KIS	75%			15%	10%	100%	9%
Total								100%

Table 1.5: Log grade mix and end-use percentages for radiata pine exported from New Zealand to South China in 2015.

End Use Percentages (%)							Total	Grade Mix
		Plywood	Appearance Lumber	Construction Lumber	Packaging Lumber	Reconstituted		
South	**P**	10%	90%				100%	5%
China	**AO**	20%	60%	20%			100%	2%
	A	80%	5%	10%	5%		100%	33%
	K	50%		20%	30%		100%	25%
	KM	100%					100%	5%
	KI	100%					100%	12%
	KIS	100%					100%	18%
Total								100%

These splits are "point in time" estimates. For example, the split between construction and packaging will vary depending on the relative strength of the construction industry and the industries that use packaging material.

3. Sawing conversion factors

Based on information obtained on our visit. The conversion factors for A grade were used for Douglas fir.

Table 1.6: Sawing conversion factors

	Conversion	Packaging	sawdust	chip
P	70	7	8	15
AO	70	7	8	15
A	68	7	8	17
K	63	7	10	20
KM	58	7	12	23
KI	65	7	9	19
KIS	50	7	14	29

Packaging refers to small packaging produced by resawing larger pieces of slabwood.

4. Remanufacturing conversion factors

Based on information obtained on our visit.

Table 1.7: Remanufacturing conversion factors

	product	sawdust	chip
P	60	15	25
AO	60	15	25
A	60	15	25

5. Sawdust use

This is an estimate.

Table 1.8: Sawdust use

	%
Burnt immediately	20
Pellets	60
Particleboard	20

6. Sawmill chip use

This is an estimate.

Table 1.9: Sawmill chip use

	%
Burnt	10
Pulp	70
Particleboard	10
MDF	10

7. Plymill conversion factors

Based on information obtained on our visit.

Table 1.10: Plymill conversion factors

conversion	core	Roundup
80	5	15

8. Ply roundup use

This is an estimate.

Table 1.11: Ply roundup use

	%
Burnt	10
Pulp	30
Particleboard	30
MDF	30

9. Plywood end use

Information was obtained on our visit.

Table 1.12: Plywood end use

	Appearance/furniture	Packaging	Construction
P	100	0	0
AO	0	10	90
A	0	10	90
K	0	10	90
KM	0	10	90
KI	0	10	90
KIS	0	10	90

10. Construction lumber recycling

This is an estimate.

Table 1.13: Construction lumber recycling

	%
Panel product	50
Burnt	50

11. Construction plywood recycling

This is an estimate.

Table 1.14: Construction plywood recycling

	%
Panel product	50
Burnt	50

12. Half-life

Table 1.15: Half-life used for each product

End use	Half- life	Source
Appearance lumber	35	IPCC Default
Construction lumber	0.5	Information obtained
Packaging lumber	3	Estimate (Nabuurs 1996)
Appearance plywood	25	IPCC Default
Construction plywood	0.5	Information obtained
Packaging plywood	3	Estimate (Nabuurs 1996)
MDF	25	IPCC Default
Particleboard	25	IPCC default
Recycled panels	2	Estimate
Veneer core	2	Estimate
Pulp	2	IPCC Default
Pellets	1	Estimate

Table 1.16: Sensitivity of average half-life to key model inputs. The average half-life is 6.6 years with base case inputs.

	Base	Low	High	*Average half-life (low)*	*Average half-life (high)*
Sawmill conversion factor		-5	+5	6.5	6.7
Production of small packaging	7	10	0	6.5	6.7
Plywood conversion factor		+5	-5	6.4	6.8
Construction lumber & plywood recycling %	50	20	80	6.3	6.9
Chip % and ply round-up % moved between pulp & particleboard		-10	+10	6.1	7.1
Appearance lumber half-life	35	30	40	6.2	7.0
Packaging lumber & ply half-life	3	1	5	6.3	6.9
Appearance ply half-life	25	20	30	6.6	6.6
MDF half-life	25	20	30	6.4	6.8
Particleboard half-life	25	20	30	6.4	6.8
Recycled panels half-life	2	1	3	6.4	6.8

Note that these estimates are "point in time" estimates and indicative for 2015.

Changing all inputs in Table 1.16 (apart from the IPCC half-lives for appearance lumber and the 3 panel products with a 25 year half-life) to low changes the average half-life to 5.5 years while high inputs change it to 7.9 years. Changing all inputs in Table 16 to low or high settings results in an average half-life of 4.4 and 9.5 years respectively.

Average half-life is also sensitive to the log grade mix, particularly the proportion of pruned logs (Table 1.17). It is also sensitive to assumptions about the assumed allocation to end-uses, particularly the allocation of AO and A to the production of appearance lumber vs construction lumber (Table 1.18).

Table 1.17: Sensitivity of average half-life to log grade mix. The average half-life is 6.6 years with base case inputs.

	Change	*Average half-life*
Increase in P grade & decrease of A grade	+5/-5	7.1
Increase in A grade & decrease of K grade	+5/-5	6.8
Increase in K grade & decrease of KIS grade	+5/-5	6.6

Table 1.18: Sensitivity of average half-life to log grade allocation between end-uses. The average half-life is 6.6 years with base case inputs.

	Change	*Average half-life*
P grade. Appearance vs plywood	+5/-5	6.6
AO/A grades. Appearance vs construction	+5/-5	6.9
A/K grades. Construction vs packaging	+5/-5	6.6

Table 1.19: Contribution of each HWP pathway to the average half-life is 6.6 years.

Initial HWP	Final HWP	Volume (million m^3)	Pathway half-life (years)	Contribution to average half-life (years)
Appearance plywood		0.06	25	0.14
Construction plywood	Panel (recycled)	1.18	2.5	0.28
	Burnt	1.18	0.5	0.06
Packaging plywood		0.26	3	0.08
Plymill residue	Burnt	0.05	0	0.00
	Pulp	0.15	2	0.03
	Particleboard	0.15	25	0.36
	MDF	0.15	25	0.36
Plymill core		0.17	2	0.03
Appearance lumber	Reman product	0.92	35	3.09
Construction lumber	Panel (recycled)	1.24	2.5	0.30
	Burnt	1.24	0.5	0.06
Packaging lumber		1.13	3	0.33
Slabwood	Burnt	0.16	0	0.00
	Pulp	1.16	2	0.22
	Particleboard	0.16	25	0.40
	MDF	0.16	25	0.40
Sawdust	Burnt	0.17	0	0.00
	Pellets	0.51	1	0.05
	Particleboard	0.17	25	0.41
Total		10.38		6.6

The average half-life of 6.6 years depends heavily on the production of appearance lumber from P, AO and A grade logs. Other pathways that are important in delaying the return of carbon to the atmosphere are:

- the use of plymill residues, sawmill slabwood and sawdust to produce panel products (MDF and Particleboard).
- panels recycled from construction lumber and plywood.
- packaging lumber.

Additional work

Visits to the 3 main log importing regions of China enable some provisional estimates. However these estimates are indicative only. It is already evident that further work will be required on each of the five key questions. For example:

What products get produced from each log grade?

More detailed information is needed on the end products produced. For example on the types of furniture that is produced from radiata pine logs and how long this furniture lasts.

What is the conversion from log to product?

Conversion factors need to be obtained for a larger sample of sawmills and plymills. Further information is also needed on the proportion of sawmills that extract small packaging from slabwood – either themselves or by others on contract.

What happens to mill residues?

Given the different product lives, the question here is what proportion of slabwood chips is used for each of paper, MDF and particleboard. Although there are many mills there are relatively few consolidators of residues. We visited two chipping operations in Shanghai/Yangtze delta and one chipping operation, an MDF plant and a particleboard plant in both Shandong and the South. It should be feasible to identify and survey all large-scale residue consolidators in each region.

What happens to construction site material after use?

The questions here are how much of this material is recycled rather than burnt and how long the recycled material lasts. The first question should be addressed by identifying and surveying large-scale consolidators of used construction site material. The second question would require the tracking though to end-use of the panel products produced from recycled plyform and construction timber.

What happens to packaging material after use?

We currently have no information on this.

2. Material flow and end use – South Korea

Background

In 2015 South Korea imported 2.6 million m^3 of logs from New Zealand, predominantly radiata pine. South Korea has been an important market for radiata pine for at least the last 20 years (Figure 2.2). A small volume of Douglas fir (about 25,000 m^3) is imported from New Zealand. About 60% of logs are imported via Incheon and 30% via Kunsan (Gunsan). Smaller volumes are imported through Pusan (Busan), Pyeongtaek and Mokpo (see Figure 2.1).

Figure 2.1: Map of South Korea showing the five ports through which New Zealand logs are imported.

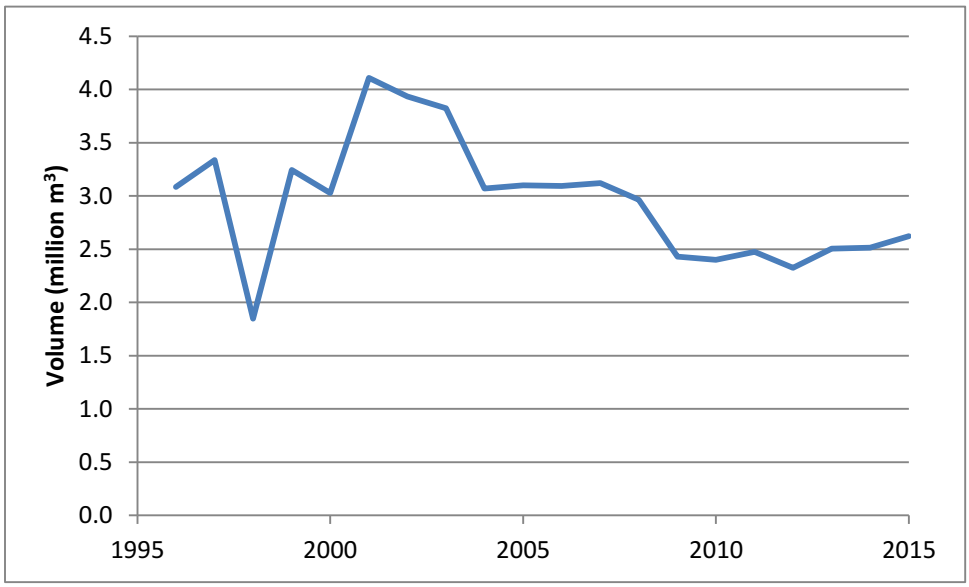

Figure 2.2: Volume of logs exported from New Zealand to South Korea. Source MPI.

The five major processing companies and log importer (Sonam Mokjae) that were visited import about half of the radiata pine volume (Table 2.1).

Table 2.1: Key features of the companies visited in South Korea.

Company	Log input (radiata pine volume m^3)	Rank in Korea (radiata pine log use)	Sawmill input (radiata pine logs m^3)	Plymill input (radiata pine logs m^3)	MDF output (total output capacity m^3)
Sunchang	600,000	1	400,000	180,000	357,000
Kwangwon	270,000	2	270,000		300,000
Aju Timber	180,000	3	180,000		
Young Do	78,000	6	78,000		
Shin Won	72,000	8	72,000		
Sonam Mokjae	60,000	9			

Main findings

Although South Korea imports a wide range of grades the dominant grades are A and K grades (Table 2.2).

Table 2.2: Indicative specifications of radiata pine export log grades with percentage of 2015 log exports to South Korea.

	Min small end diameter (cm)	Max branch size (cm)	% of 2015 volume
P	30 (or 34 or 40)	0	5
AO	40	10	1
A	30	10	50
K	20	10	30
KM	16	7	4
KI	30	20	8
KIS	10	no limit	2

What products get produced from each log grade?

- Pruned logs are sawn for furniture and peeled to produce clear veneer for plywood.
- AO logs are sawn for furniture.
- A and K logs are sawn for construction and packaging lumber and peeled for plywood.
- KM and KI logs are sawn for construction and packaging lumber.
- KX/KIS are sawn for construction and packaging lumber or chipped for MDF.
    - For example, Sunchang buy a KIS/Pulp grade that is scanned and sorted with better logs sawn and poorer logs chipped for MDF.
- Douglas fir logs are primarily processed into construction lumber.

Sawmills have been encouraged to consolidate capacity and move to land adjacent to ports in order to reduce log transport costs. Korean sawmills (Figures 2.3 to 2.5) are typically larger scale than Chinese or Indian mills, but still use quite a lot of labour and do not have the levels of technology of a modern New Zealand mill. Mills are frequently operated by MDF companies who require the fibre. Independent mills have agreements to supply residue to local MDF companies.

Figure 2.3: Band saw headrig

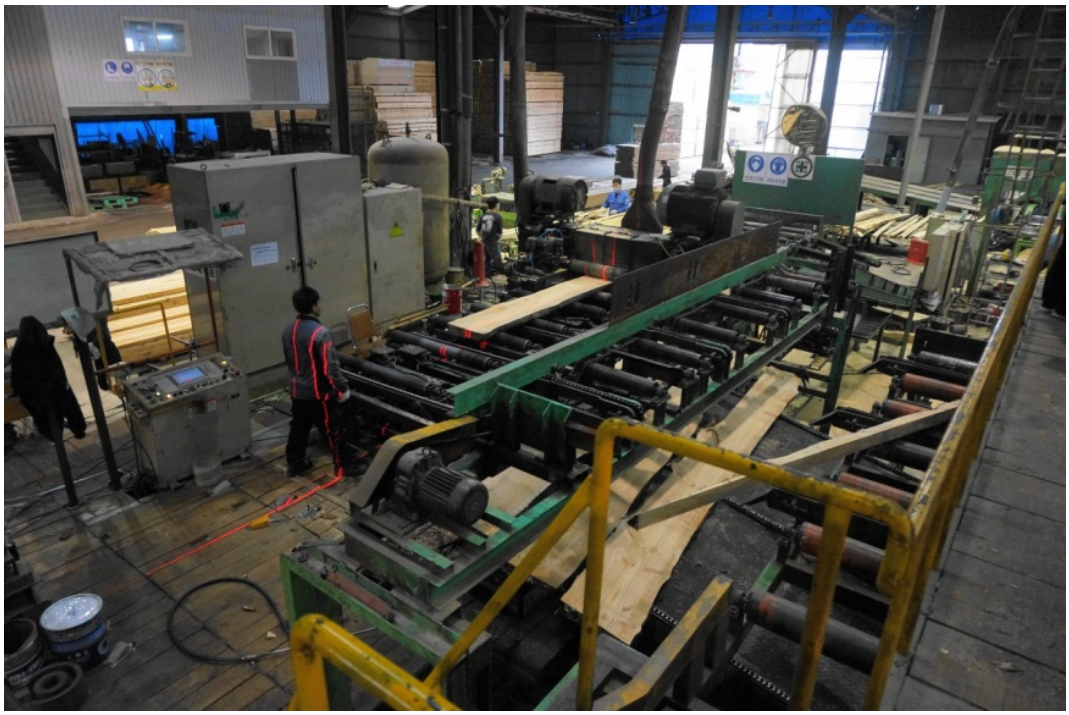

Figure 2.4: Edger

Figure 2.5: Manual sorting and stacking

What are these products used for?

Lumber

- Construction lumber has two types of use:
    - Civil construction
        - concreting for foundations of buildings and bridges.
        - subway construction.
        - underground concrete retaining walls.
    - Formwork/plywood support (see Figures 2.7 and 2.8).
- Packaging lumber is used for:
    - Pallets for domestic & export markets.
    - Cable drums.
    - Packaging around export products.
        - For example; packing car parts sent abroad for assembly
- Furniture including table tops.

For the A, K, KM, KI and KIS grades the proportion of lumber used for construction varies from 60 to 85% with a weighted average of 70%. The balance is used for packaging.

Plywood is used for:

- Construction.
- appearance plywood for interior design including decorative panels.

MDF is used for:

- Furniture particularly kitchen cabinets and benchtops.
- Doors.

Figure 2.6: Construction lumber produced from radiata pine

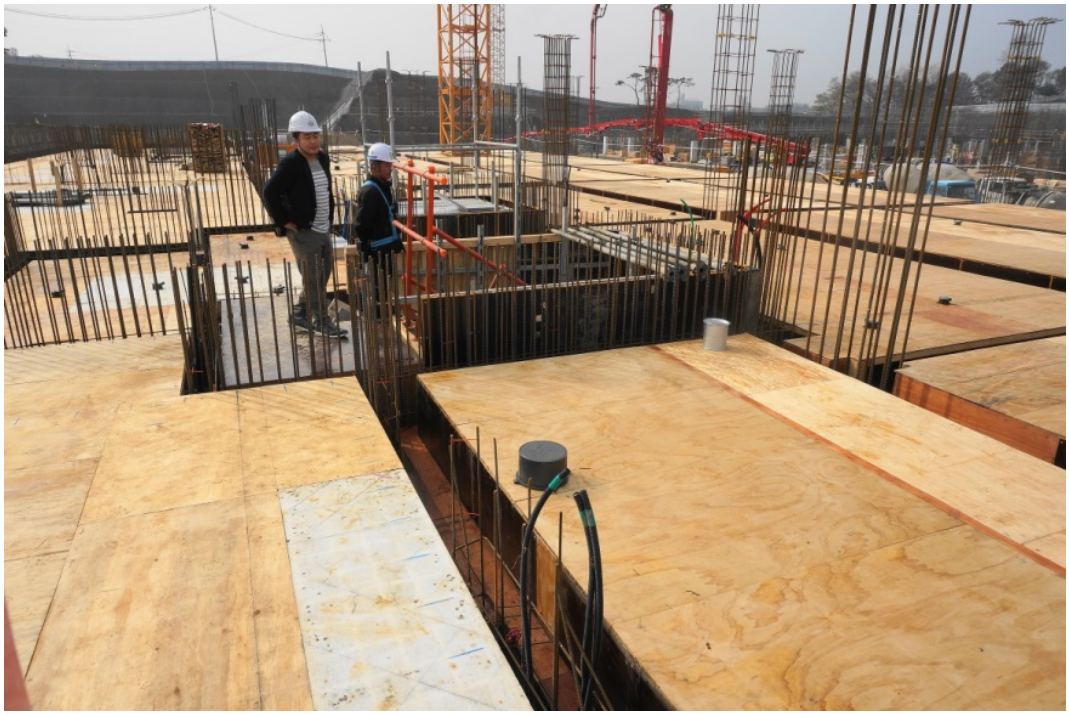

Figure 2.7: Use of plywood in concrete formwork

Figure 2.8: Use of sawn timber and plywood for concrete formwork

Figure 2.9: Packaging timber produced from radiata pine A grade log.

What is the conversion from log to product?

- Conversion at the 4 sawmills visited which use a bandsaw headrig (to primarily saw A grade logs) varies from 62 to 70% (median 65%) with:
    - 10% sawdust.
    - 25% slabwood.
- Conversion at the sawmill visited which uses an Ari chipper canter (to saw K, KM and KIS logs) varies, depending on log grade, from 40 to 55% with:
    - 15% sawdust.
    - 30 to 45% chip.
- Primary conversion at the plymill was:
    - 56 to 60% to veneer/plywood depending on log grade.
    - 40 to 44% to roundup and cores.
    - We were advised that other companies were achieving 65% conversion using spindle-less lathes.

What happens to mill residues?

- Sawdust is:
    - Used by Sunchang for boiler fuel to provide steam for plywood plant and power for the company to use.
    - Sold by other companies to traders for:
        - Fertiliser (ie mulching).
        - Animal beds particularly for pig farming.
        - Crab boxes to cushion crabs and keep them away from other crabs.
- Other mill residues (including slabwood and veneer roundup and cores) are used for the production of MDF.

Figure 2.10: Sawmill slabwood is used for MDF production

Figure 2.11: MDF plant. Radiata pine slabwood on left. Local pine logs on trucks.

What happens to construction site material after use?

- Construction timber and plyform is used about 3 times on the construction site until it is no longer fit for purpose.
    - Most of it is then chipped and used for particleboard.
- Some may be used as fuel and burnt.

Figure 2.12: Used lumber at a construction site

What happens to packaging material after use?

- We did not obtain any information on this.

South Korea HWP Model

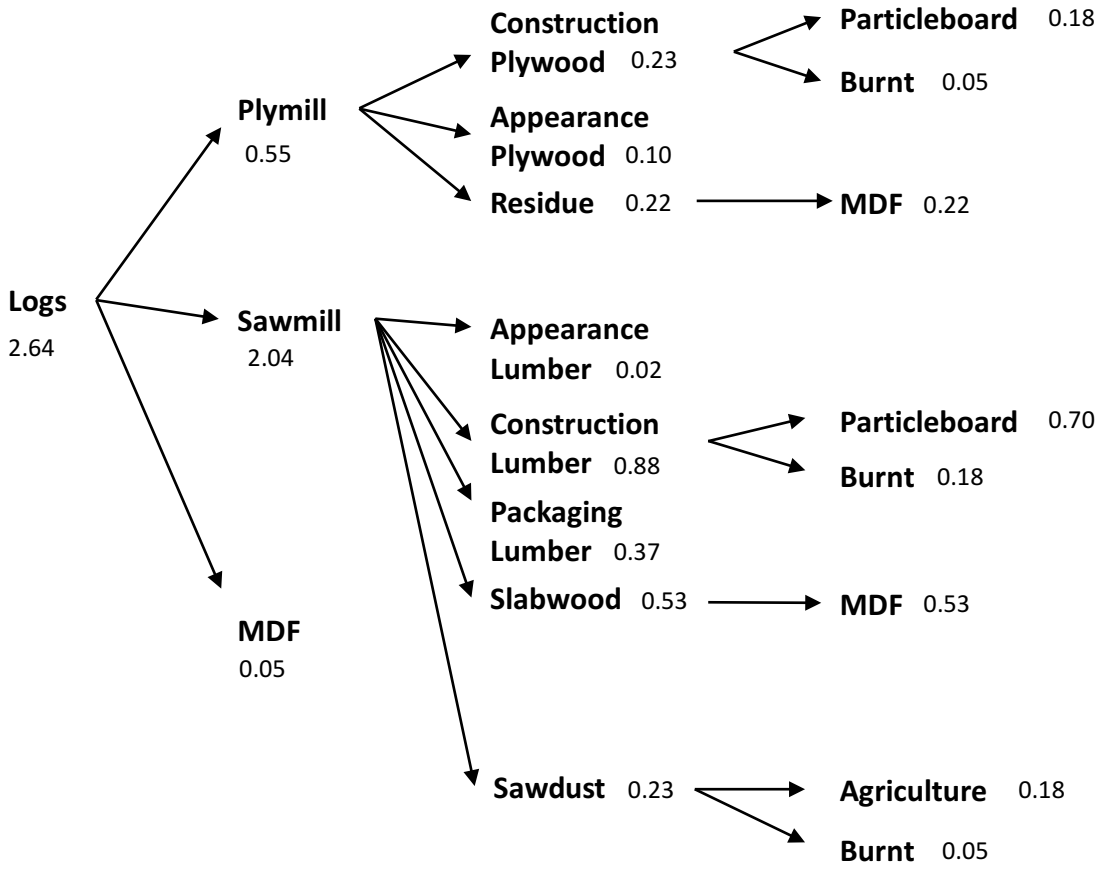

Figure 2.13: Outline of material flow with volume estimates (in million m^3 roundwood equivalent) for 2015. Volume estimates are indicative only.

Inputs to the model

1. Log grade mix

This information came from New Zealand log exporters.

2. End Use percentages

Base information came from New Zealand log exporters. This was confirmed by observations and information obtained on our visit.

Table 2.3: Log grade mix and end-use percentages for radiata pine exported from New Zealand to South Korea in 2015.

End Use Percentages (%)							Total	Grade Mix
		Plywood	Appearance Lumber	Construction Lumber	Packaging Lumber	Reconstituted (MDF)		
Korea	**P**	95%	5%				100%	5%
	AO		100%				100%	1%
	A	20%		60%	20%		100%	50%
	K	20%		50%	30%		100%	30%
	KM			45%	55%		100%	4%
	KI			80%	20%		100%	8%
	KIS					100%	100%	2%
Total								100%

These splits are "point in time" estimates. For example, the split between construction and packaging will vary depending on the relative strength of the construction and packaging-using industries.

3. Sawing conversion factors

This information was obtained on our visit.

Table 2.4: Sawing conversion factors

	conversion	sawdust	chip
P	70	10	20
AO	70	10	20
A	65	10	25
K	60	12.5	27.5
KM	52	15	33
KI	62	12.5	25.5
KIS	42.5	17.5	40

4. Plywood conversion factors

This information was obtained on our visit.

Table 2.5: Plywood conversion factors

	conversion	residue
P	62	38
A	60	40
K	58	42

5. Plywood end use

This information was obtained on our visit.

Table 2.6: Plywood end use

End use	%
Appearance	30
Construction	70

6. Construction lumber recycling

This is an estimate.

Table 2.7: Construction lumber recycling

	%
Particleboard	80
Burnt	20

7. Construction plywood recycling

This is an estimate.

Table 2.8: Construction plywood recycling

	%
Particleboard	80
Burnt	20

8. Sawdust use

This is an estimate.

Table 2.9: Sawdust use

	%
Agriculture	80
Burnt	20

9. Half-life

Table 2.10: Half-life used for each product

End use	Half-life	Source
Appearance lumber	35	IPCC Default
Construction lumber	0.5	Information obtained
Packaging lumber	3	Estimate (Nabuurs 1996)
Appearance plywood	25	IPCC Default
Construction plywood	0.5	Information obtained
MDF	25	IPCC default
Particleboard	25	IPCC default
Sawdust (agriculture)	1	Estimate

Table 2.11: Key inputs to model and the sensitivity of average half-life to each input. With base case inputs the average half-life is 18.0 years.

	Base	Low	High	*Average half-life (low)*	*Average half-life (high)*
Sawmill conversions		-5	+5	18.1	17.9
Plywood conversions		-5	+5	18.0	18.0
Sawmill Construction % (vs packaging)	70	50	90	16.3	19.7
Construction lumber & plywood recycling %	80	70	90	16.9	19.0
Sawdust % for agriculture	80	60	90	18.0	18.0
Appearance lumber half-life	35	25	50	17.9	18.1
Construction lumber/ply half-life	0.5	0.25	1	17.9	18.2
Packaging lumber half-life	3	1	5	17.7	18.3
Appearance ply half-life	25	20	30	17.8	18.2
MDF half-life	25	20	30	16.5	19.5
Particleboard half-life	25	20	30	16.3	19.7
Sawdust (agriculture) half-life	1	0.5	2	18.0	18.1

Note that these estimates are "point in time" estimates and indicative for 2015.

Sensitive assumptions are:

- Sawmill Construction % (vs packaging)
    - Determines percentage of wood that ultimately goes into particleboard via temporary construction compared to relatively short-lived packaging.
- Construction lumber & plywood recycling %
    - Determines percentage of temporary construction material that is recycled into particleboard rather than being burnt.
- Particleboard half-life
    - A high percentage of wood ends up in this product.
- MDF half-life
    - An important product.

Changing all inputs in Table 10 (apart from the IPCC half-lives for appearance lumber and the 3 panel products) to low changes the average half-life to 14.8 years while high inputs change it to 21.3 years. Changing all inputs in Table 10 to low or high settings results in an average half-life of 11.9 and 25.4 years respectively.

Table 2.12: Contribution of each HWP pathway to the average half-life is 18.0 years.

Initial HWP	Final HWP	Volume (million m^3)	Pathway half-life (years)	Contribution to average half-life (years)
Construction plywood	Particleboard	0.18	25.5	1.77
	Burnt	0.05	0.5	0.01
Appearance plywood		0.10	25	0.93
Plymill residue	MDF	0.22	25	2.08
Appearance lumber		0.02	35	0.31
Construction lumber	Particleboard	0.70	25.5	6.81
	Burnt	0.18	0.5	0.03
Packaging lumber		0.37	3	0.42
Slabwood	MDF	0.53	25	5.05
Sawdust	Agriculture	0.18	1	0.07
	Burnt	0.05	0	0.00
MDF		0.05	25	0.50
Total		2.64		18.0

The average half-life of 18.0 depends heavily on:

- Particleboard recycled from construction lumber and plywood.
- MDF produced from logs, sawmill slabwood and plymill residues.

Additional work

Our visit to South Korea gave us an overview of the forestry value chain. We visited companies that collectively import 1.2 million m^3 of radiata pine from New Zealand. This is about 50% of the log export volume from New Zealand to South Korea. Consequently we are able to make provisional estimates on the duration of harvested wood products. However these estimates are indicative only. It is already evident that further work will be required on each of the key questions. For example:

What products get produced from each log grade?

Our estimates would be more robust if we also had information for other large log importers (e.g. Unid, Hansol and Poongil) and other plywood producers (e.g. Eagon, Dongil and Sungchang).

What are these products used for?

We were able to visit a construction site to see the use of radiata pine construction lumber and plyform. However we did not visit any civil construction sites to see how radiata pine products are used (and what their ultimate end-use is).

One New Zealand log exporter told us that a significant use of radiata pine was as treated lumber in retaining walls. However we did not see any evidence of this and did not see any treatment plants apart from anti-sapstain dips. This requires further clarification.

We also did not visit any sites where radiata pine was being used for packaging.

What is the conversion from log to product?

Conversion factors were similar for sawmills using a band headrig but the chipper canter conversion was much lower. It would be useful to also have information for other large sawmills so that an appropriate weighted average conversion factor could be derived for South Korea.

Our veneer conversion factor is based on a single mill. It would be useful to have information for other plywood plants.

What happens to construction site material after use?

It appears that the majority of lumber and plywood used for formwork is recycled and ultimately chipped and used for particleboard. To confirm this it would be necessary to survey particleboard plants for the source of their raw material; i.e. carry out a material balance exercise for particleboard raw material.

It would also be necessary to assess the quality and expected life of the particleboard produced.

What happens to packaging material after use?

We currently have no information on this.

3. Material flow and end use - India

Background

In 2015 New Zealand exported 1.6 million m^3 of logs to India, all radiata pine. There has been a rapid increase over the last 10 years (Figure 3.2). The majority of logs are exported to the ports of Kandla and Mundra in Gujarat state in the north-west of India. A small but increasing proportion was exported to Tuticorin in southern India. In 2015 we visited both regions and also Bangalore and New Delhi.

Figure 3.1: Map of India showing the two regions where New Zealand logs are imported and processed.

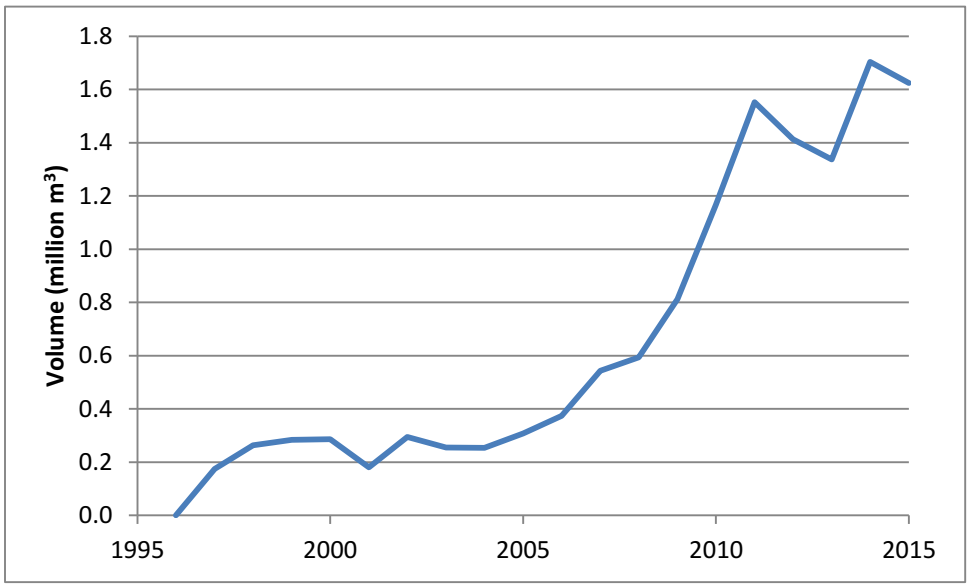

Figure 3.2: Volume of logs exported from New Zealand to India. Source MPI.

Main findings

Log grades exported to India are A (39%), K (25%), KI (26%) and KIS (10%). The seven mills that we visited in southern India process between 6,000 and 30,000 m^3 of radiata pine per year compared to between 12,000 and 132,000 m^3/year for the six mills that we visited in Gandhidham in Gujarat province. Some mills have a preference for particular grades but typically get supplied with a mix. All grades tend to be cut the same way although one miller uses K & KI grades for construction but uses A grade for small sizes (pallets) because they believe that it has fewer knots.

Sawmills almost invariably consist of a set of a horizontal bandsaw for initial breakdown (Figure 3.3) in tandem with a vertical band resaw (Figure 3.4). Only one larger scale mill (a Woodmizer) was seen, and it was reported that most attempts to increase the scale of the sawmilling industry had not been successful.

Figure 3.3: Horizontal bandsaw for primary breakdown.

Figure 3.4: Vertical bandsaw (secondary breakdown).

Blockboard blanks are extracted from slabwood in a separate operation elsewhere on site (Figures 3.5 and 3.6).

Figure 3.5: Docking blockboard blanks (produced by ripping slabwood).

Figure 3.6: Laying up blockboard blanks in jig (note larger dimension frame timber).

What is the conversion from log to product?

- Sawmill conversion of the 14 sawmills that we visited varies from 65 to 77% (average 71%). Residues are assumed to be split 50/50:
    - 14.5% sawdust.
    - 14.5% firewood.
- The conversion % includes 4 to 27% blockboard (average 13%). Most mills produce 8 to 16% blockboard – primarily small blanks. Mills that produce a higher percentage also produce lumber for blockboard frames. The mill that produces 27% blockboard has its own plywood/blockboard plant.

What products get produced from each log grade?

- Construction lumber
    - Battens
- Packaging lumber
    - Pallets
    - Boxes
    - Crates
- Blockboard
    - Partitions
    - Flush doors
- Furniture – a small quantity is used.
- Cooling towers – a small quantity is used.

The split between construction lumber and packaging lumber from individual mills varies from 0 to 100%. The average split of the mills visited is 47% construction and 53% packaging. This split excludes blockboard which is considered to be a by-product or arising at most mills.

Construction material is almost exclusively used as battens to hold plywood in place for concrete formwork. Typically 90*62 mm battens are used for holding up floors with 62 * 45 mm battens used for walls. Steel rather than wooden supports are used.

Some mills produce pallets but most packaging material was supplied directly to packaging plants that are co-located with a major plant that produces pharmaceuticals, glass, auto parts and accessories, turbines/electric motors/generators, or electronics. Packaging includes crates and boxes as well as pallets. Most radiata pine pallets are used for export. Domestic “junglewood”, often eucalypts, is commonly used for domestic pallets because it is cheaper. Some fruit boxes (e.g. mangoes) are made of pine as cardboard boxes are easily damaged in the Indian distribution system.

Figure 3.7: Construction lumber being used as battens to support plywood in concrete boxing.

Figure 3.8: Construction lumber being used as battens to support plywood in concrete boxing.

Figure 3.9: Pallets produced from radiata pine.

Figure 3.10: Broken pallets are repaired for re-use. Broken components are shown here.

Blockboard blanks are produced from slabwood. Non-standard sizes ("off-sizes") are also used for blockboard frames (i.e. edges). Radiata pine is not used for the face veneer on blockboard. Radiata pine is not peeled in India. Instead other species, imported or domestic, are used.

Figure 3.11: Blockboard core produced from radiata pine.

Figure 3.12: Finished blockboard. Note that the reference to "New Zealand Pinewood" refers to the core. The face veneers are locally grown Melia.

What happens to mill residues?

- Residual slabwood (after extraction of blockboard blanks) is used for fuel.
- Sawdust is predominantly used for fuel. Some sawdust is used for particleboard production.

Figure 3.13: Truck loaded at Gandhidam (Gujarat state) with residual slabwood that is used for fuel at nearby ceramic and textile plants.

Figure 3.14: Slabwood used for fuel in boiler for kilns and hot air seasoning.

Figure 3.15: This truck of sawdust was destined for a particleboard plant. However most sawdust is used for fuel.

What happens to construction site material after use?

- Construction timber is reused about 4 times and then used for fuel.
    - Expected life is 6 months.

Figure 3.16: Construction site "waste".

What happens to packaging material after use?

- Most (>70%) of packaging timber is used for exports. This may be recycled.
- Domestic packaging timber is sometimes recycled but is mostly burnt after use.

Figure 3.17: Recycling of wood in Kirti Nagar, Delhi.

What is the life of other products?

- Blockboard
    - Flush doors - 20 years
    - Partitions - 10 years
- Cooling towers - 15 years

Model

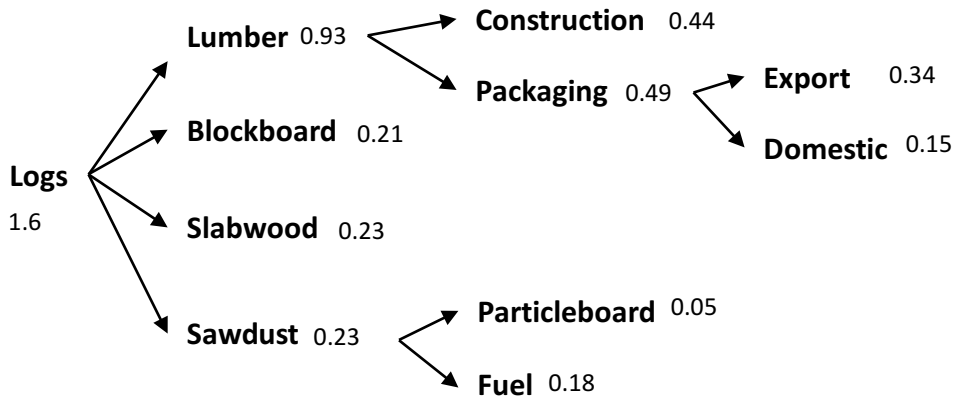

Figure 3.18: Outline of material flow with volume estimates (in million m^3 roundwood equivalent) for 2015. Volume estimates are indicative only.

Inputs
Most mills took a mix of log grades. It is assumed that all log grades are converted in the same proportions.

There is no differentiation made between processing in Gujarat and southern India

% Log converted to lumber + blockboard
Average of 14 mills (weighted by log input) is 71%. The range was 67% to 77%. The low and high values are based on 95% confidence intervals for the mean.

% Log converted to lumber
Average of 14 mills (weighted by log input) is 58%. The range was 39% to 71%. This depended on the relative priority placed on blockboard production. The low and high values are based on 95% confidence intervals for the mean.

% Log converted to blockboard
Average of 14 mills (weighted by log input) is 13%. The range was 4 to 27%. The low and high values are based on 95% confidence intervals for the mean.

% Lumber that is packaging
Average of 14 mills (weighted by log input) is 53%.The range was 0 to 100%. This percentage varies depending on market conditions and had been lower in 2014 when there was greater construction activity.

% of residue that is sawdust
It was difficult to consistently get quantitative information on residues. The base value of 50% is arbitrary as are the limits.

% of packaging that is exported

Many southern mills said that 90 to 100% of packaging from their radiata pine was used for exports whereas Gujarat sawmills had a higher percentage used for domestic packaging – for example radiata pine was used for packaging of glass for the domestic market because it was it was a better shock absorber and less prone to break than eucalypts. An estimate of 70% is used.

% of sawdust used for particleboard

Sawdust was typically sold to a trader who on-sold. An estimate of 20% is assumed for the percentage of sawdust that is used for particleboard. The balance of sawdust is used for fuel.

Table 3.1: Half-life assumed for each product

End use	Half- life	Source
Construction lumber	0.5	Information obtained
Export packaging	3	Estimate (Nabuurs 1996)
Domestic packaging	0.5	Information obtained
Blockboard	7	Information obtained
Particleboard	25	IPCC default
Sawdust fuel	0.25	Estimate
Fuelwood	0.25	Estimate

Table 3.2: Key inputs to model and the sensitivity of average half-life to each input. With base case inputs the average half-life is 2.5 years. With all "low" inputs the average half-life is 0.7 years. With all "high" inputs the average half-life is 8.5 years.

	Base	Low	High	*Average half-life (low)*	*Average half-life (high)*
% Log converted to lumber + blockboard	71	69	73	*2.5*	*2.5*
% Log converted to blockboard	13	9	17	*2.3*	*2.7*
% Lumber that is packaging (balance is construction)	53	20	80	*2.2*	*2.8*
% of residue that is sawdust (balance is slabwood)	50	25	75	*2.2*	*2.8*
% of packaging that is exported	70	50	90	*2.3*	*2.7*
% of sawdust used for particleboard (balance is used for fuel)	20	0	40	*1.8*	*3.2*
Half-life – construction	0.5	0.25	1	*2.4*	*2.6*
Half-life – export packaging	3	1	5	*2.1*	*2.9*
Half-life – domestic packaging	0.5	0.25	1	*2.5*	*2.5*
Half-life – blockboard	7	5	25	*2.2*	*4.8*
Average half-life	*2.5*	*0.7*	*8.5*		

Note that these estimates are "point in time" estimates and indicative for 2015.

Changing all inputs in Table 2 (apart from half-lives) to low changes the average half-life to 1.2 years while high inputs change it to 4.6 years. Changing all inputs in Table 2 to low or high settings results in an average half-life of 0.7 and 8.5 years respectively.

Table 3.3: Contribution of each HWP pathway to the average half-life is 2.5 years.

Initial HWP	Final HWP	Volume (million m^3)	Pathway half-life (years)	Contribution to average half-life (years)
Construction lumber		0.44	0.5	0.14
Packaging lumber	Export	0.34	3	0.65
	Domestic	0.15	0.5	0.05
Blockboard		0.21	7	0.91
Slabwood		0.23	0.25	0.04
Sawdust	Particleboard	0.05	25	0.72
	Fuel	0.18	0.25	0.03
		1.60		2.5

The average half-life of 2.5 depends heavily on:

- blockboard.
- sawdust being used for particleboard.
- export packaging lumber.

Additional work

Our visit to India enables us to make an estimate of the average half-life of products produced from New Zealand log exports. However these estimates will be indicative only. It is already evident that further work will be required on the key questions. For example:

What products get produced from each log grade?

More detailed information is needed on the end products produced. In particular the proportion of packaging lumber used for exports.

What is the conversion from log to product?

Conversion factors provided by Indian sawmillers are calculated using log volumes calculated in Hoppus feet rather than cubic feet with 1 hoppus foot equal to 1.273 cubic feet (27.74 hoppus feet = 1 m^3). Consequently the conversion factors calculated needed to be scaled down by 0.7854 (= $\pi/4$). We assumed that the balance of volume ended up in equal volumes of firewood and sawdust. This assumption needs to be checked particularly as some sawdust is used to produce particleboard.

What happens to packaging material after use?

Further information is needed on how long packaging used for export products is used for. A breakdown of the use of packaging for domestic products is also required.

What happens to mill residues?

Given the different product lives, the question here is what proportion of sawdust is used for fuel and particleboard.

Half-lives

Further information is required to confirm half-life estimates for export packaging, domestic packaging and blockboard.

Reference

Nabuurs, G.J. 1996. Significance of wood products in forest sector carbon balances. In: Forest Ecosystems, Forest Management and the Global Carbon Cycle. NATO ISI Series, Springer-Verlag, Berlin, Germany.