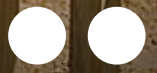




SUSTAINABLE PERFORMANCE
NEW ZEALAND PINE

NEW THINKING.



CONTENTS

New Zealand overview	03		
New Zealand pine - the super renewable wood	04	Furniture and components	46
New Zealand pine properties	06	Engineered wood products	48
New Zealand pine performance	09	Plywood and LVL	50
Renewable and sustainable forest resource	11	Addressing engineering consistency with LVL	53
Pruning produces quality clear wood	16		
		Wood building solutions	55
Log conversion	18	Construction	56
Lumber and grades	19	Joinery and interior fittings	61
Protection in transit	24	Industrial use	63
Drying	27		
Preservative treatments	32	Useful web links	65
Working with New Zealand pine	36	Case studies	66
Machining	37	Bodyguard Wood Products	
Gluing	39	Lockwood Group	
Finishing	42	McIntosh Timber Laminates	
Mouldings and millwork	44	Verda New Zealand	
		NZTE contact details	75



THE NEW ZEALAND STORY

YOU ARE HERE. IN A DIFFERENT PLACE AND SPACE. THIS IS NEW ZEALAND, A LAND APART, WHERE GEOGRAPHIC ISOLATION FORGED BOTH A LAND OF SPECTACULAR BEAUTY AND AN INDEPENDENT SPIRIT YOU'D EXPECT FROM THE YOUNGEST COUNTRY ON EARTH. A RESPECT FOR THE LAND, WITH THE HANDS ON ABILITY TO MAKE THINGS WORK. AN INVENTIVE PEOPLE DRIVEN TO FIND THEIR OWN WAY, TO CHALLENGE THE EXPECTED. WHERE NEW IS IN OUR NAME, WITH A FUSION OF DIVERSE CULTURES CREATING A FRESH EXPRESSION UNLIKE ANYTHING ELSE YOU'LL EVER EXPERIENCE. HERE. REFRESHING NEW PERSPECTIVES... ON OUR PLACE, FROM OUR PEOPLE, ON YOUR WORLD.



NEW ZEALAND

Comparable in size to the United Kingdom but with a population of four million, New Zealand is one of the world's least crowded countries. Its vast open spaces, temperate climate, diverse culture and pure natural environment make it one of the world's top travel destinations.

New Zealand has a stunning variety of landforms - from spectacular alpine glaciers and massive mountain ranges to rolling green farmland and long, sandy beaches. It is also the home of unique flightless birds such as the kiwi, the world's heaviest insect and a "living dinosaur" - the tuatara lizard.

Vast pine plantations were established last century - protecting the remaining indigenous forests and providing a timber resource for future economic growth.

The Maori people were the first to settle in New Zealand 1000 years ago, followed much later by British colonisation. Modern New Zealand is a progressive and enterprising country, with residents drawn from all corners of the globe - including the world's biggest Polynesian population.



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The home of New Zealand pine is a spectacularly beautiful country of vast mountain chains, steaming volcanoes, sweeping coastlines, deeply indented fiords and lush rainforests.

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NEW ZEALAND PINE - THE SUPER RENEWABLE WOOD

New Zealand-grown *Pinus radiata* is a “super softwood” of the 21st century – one of the most attractive and versatile industrial wood species available in global markets. It performs consistently well across a wider range of commercial applications when compared with almost any other species – including all of the following categories:

Joinery and interiors

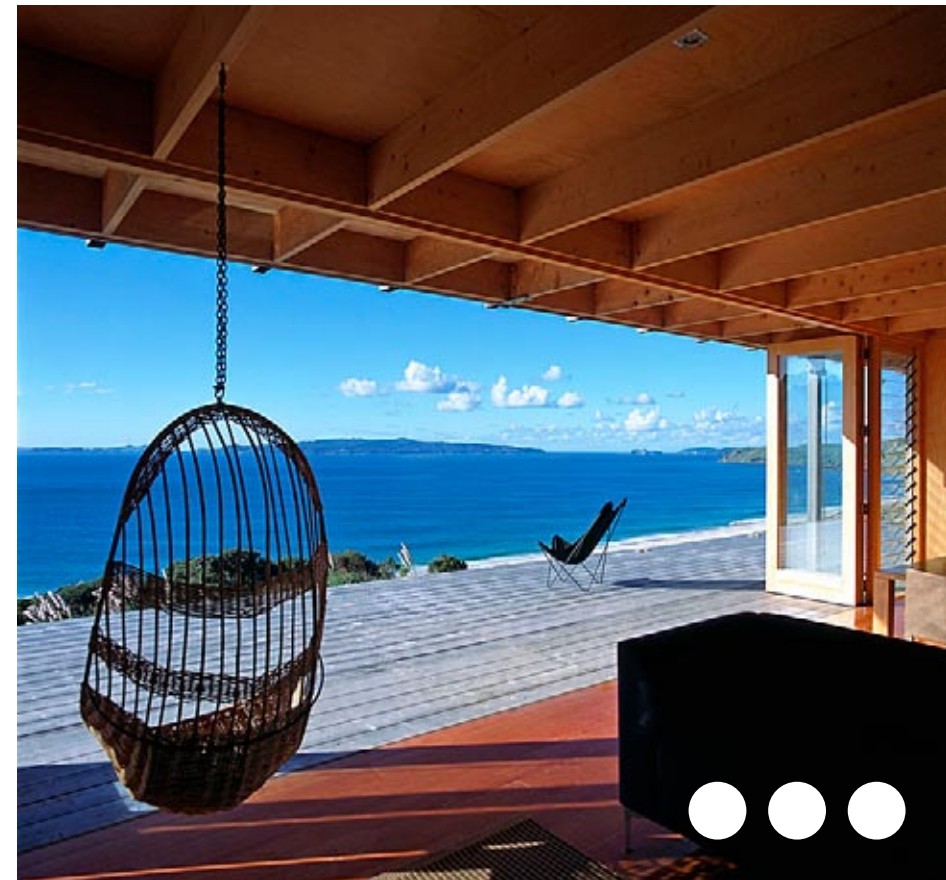
Favoured for windows, doors, frames and jambs, mouldings, stairs, cabinetry and bench tops. Solid-clear, finger-jointed and laminated product options are available.

Furniture and components

Excellent technical properties, finishes easily in natural or enhanced colours and is adaptable to most furniture styles. Demand for partially and fully processed components includes: blanks, edge-glued panels, clear and finger-jointed cut stock for further remanufacture, mouldings, stair parts, door and window parts and furniture components.

Construction and packaging

Strength, stiffness and good working properties make pine a popular choice for 2x4 and post-and-beam construction. Also used widely for pallets, wooden packaging and cable drums.



Round wood

Posts and poles made from preservative-treated pine outperform all other softwoods, and most hardwoods, in a wide range of high-hazard outdoor situations.

Engineered wood

Pine is used widely in the manufacture of glued-laminated timber (glulam), laminated veneer lumber (LVL), plywood and several other engineered wood products.

Veneers and overlays

The timber can be sliced or peeled to produce high-quality, natural clear veneer for a variety of products, including engineered door stiles, curved plywood, overlaid panels and medium density fibreboard (MDF).

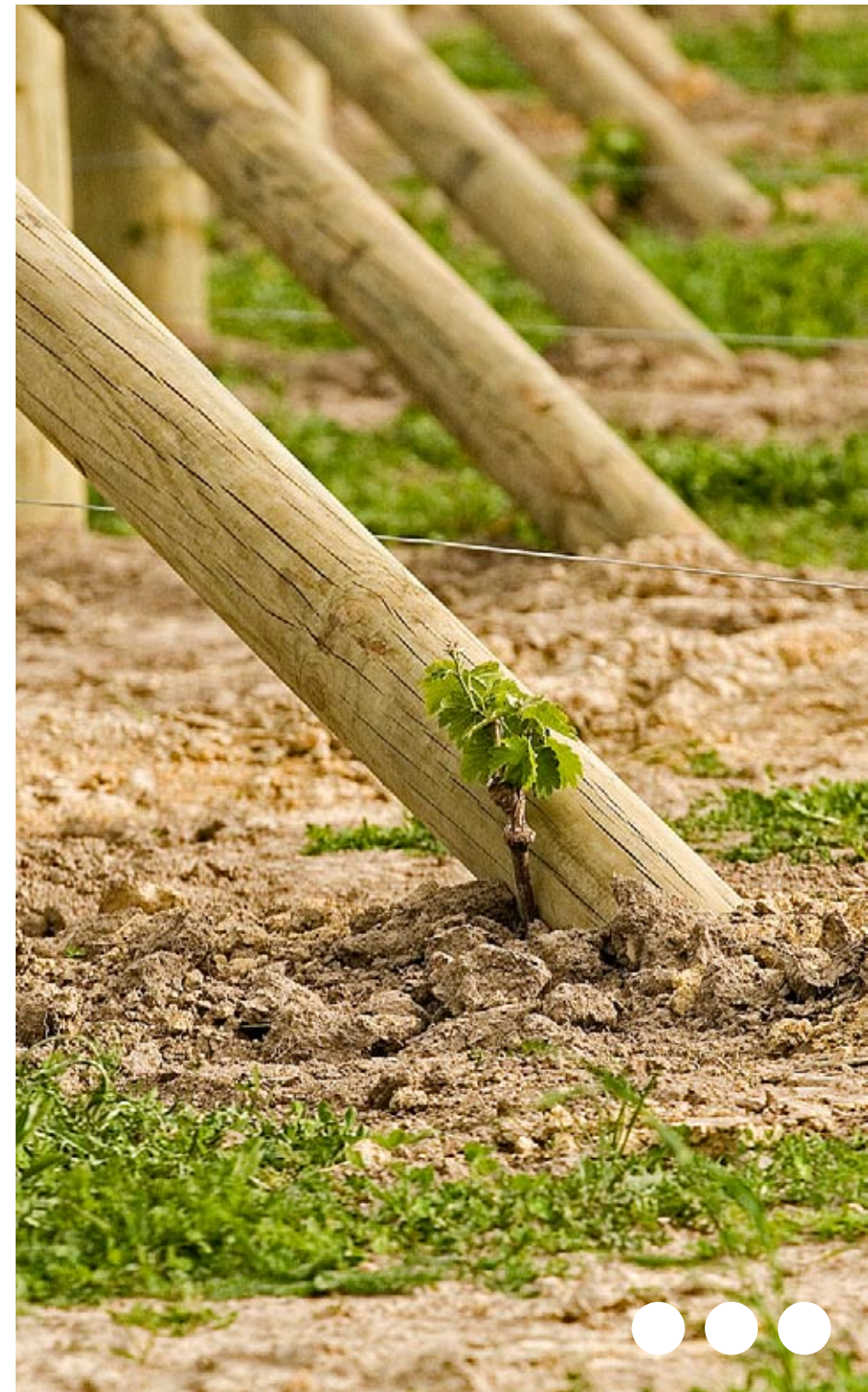
MDF and particleboard

Pine fibre is favoured by producers of high-quality MDF because of its colour, consistent high quality and the surface finish that can be achieved. Particleboard, fine particleboard and MDF-strandboard are among other panel options.

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Excellent technical
properties, finishes easily
in natural or enhanced
colours and adaptable to
most furniture styles.

.....



NEW ZEALAND PINE PROPERTIES

New Zealand pine is widely known throughout the Asia-Pacific region as an excellent packaging and general-purpose building timber, but this extremely versatile timber is also favoured for many other uses.



Product characteristics

The following description of the physical characteristics is intended to provide preliminary technical advice for current and intending users.

Names

New Zealand pine, radiata pine, white pine, Monterey pine, *Pinus radiata*.

Density

Medium density ensures versatility. Average tree density (oven-dry weight/green volume) is lower near the pith and higher near the bark. It varies with growth site and age from around 390 kilograms per cubic metre (kg/m^3) for 25-year-old trees on a low-density site to around 460 kg/m^3 for 45-year-old trees on a high-density site. A 30-year-old tree on a medium-density site has a density of around 415 kg/m^3 .

Strength

The timber compares favourably with other species in bending strength, bending stiffness and fastening. Under JAS 600, pine is rated equal to species in the spruce-pine-fir (SPF) classification used in the United States and Canada. Shear strength is excellent – a factor of its uniform texture.

Permeability

Pine forms heartwood at about 15 years and progresses slowly. At 30 years about 20% of the stem is heartwood. High permeability of the sapwood makes it easy to dry and treat with preservatives. Heartwood is less permeable than the sapwood, but dries readily and can also be effectively preservative treated. When exposed to the possibility of decay, the timber should be preservative treated.

Sap stain

Although sap stain fungi will colonise and discolour sapwood, it has no influence on general wood properties. The sapwood is susceptible to insect attack, particularly to the larvae of the *Anobium punctatum* furniture borer beetle, but kiln drying reduces that likelihood.

Shrinkage and stability

Pine has good stability and low-to-moderate shrinkage. It compares well with most other softwoods. From green to dry (12% moisture content [mc]) it shrinks, on average, 3.9% tangentially and 2.1% radially, which is slightly less than for Douglas fir. Stability can be improved by high-temperature drying or quarter sawing.

Colour

Pine has a light-coloured sapwood with slightly darker heartwood. Exposure to the sun leads to a yellowing of both heartwood and sapwood. No special finishing techniques are needed for a uniform finished appearance.

Mechanical properties

The mechanical properties of sawn lumber are closely related to knot size and density. Because density increases with distance from the centre of the tree, mechanical properties follow that characteristic. Properties, particularly density, increase as ring width decreases (ring width generally decreases with distance from the centre of the tree). Typical mechanical properties for clear-grade, 30-year-old material (20-millimetre [mm] standard specimens) are shown on the right.

Earlywood and latewood densities

Species	Basic Density (kg/m ³)	
	Earlywood	Latewood
Radiata pine	350	550
Balsam fir	340	610
Sitka spruce	330	575
Lodgepole pine	360	630
Ponderosa pine	315	580
Douglas fir	300	690
Western hemlock	390	615

Source: Scion

Shear strength is excellent –
a factor of its uniform texture.

Typical mechanical properties

(based on standard 20 x 20mm defect-free samples)

Property (12% mc)	Units	Range
Density	kg/m ³	400-500
Bending stress at proportional limit	MPa	35-45
Modulus of rupture	MPa	80-100
Modulus of elasticity	GPa	7-10
Work to maximum load	kJ/m ³	80-110
Compression at proportional limit	MPa	20-30
Compression strength	MPa	35-45
Shear strength	MPa	10-13
Side hardness	N	3000-4500
Shrinkage (wet to 12% mc)		
Tangential	%	3.5-4.5
Radial	%	1.5-2.5
Longitudinal	%	0-0.5

Source: Scion



NEW ZEALAND PINE PERFORMANCE

Independent scientific studies consistently prove that New Zealand pine performs better than most of the world's widely available renewable softwoods - and many hardwoods.

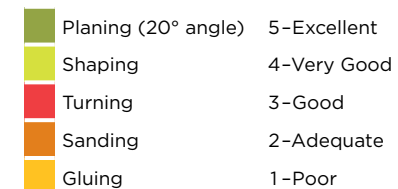
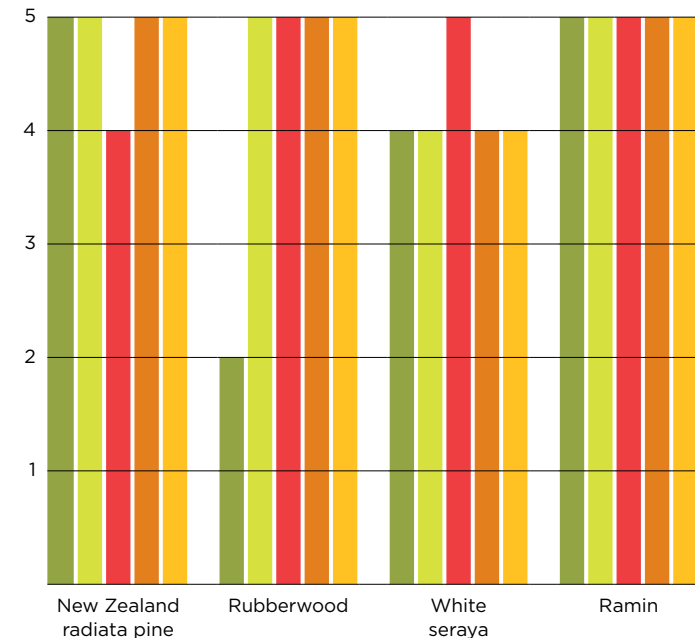
Pine outperforms major competing timbers from North America, Europe and the tropics. In a Scion (New Zealand) comparison of machining and mechanical properties with 13 similar North American species, New Zealand pine finished a clear winner, with an overall score of 70% against an average score of 59%.

It also performs well against many higher-priced tropical species, including ramin, nyotah, white seraya, jelutong, rubberwood and tusam. Overall differences are so small compared with these species that pine could easily replace any one of them for most uses.

The machining qualities of pine have also been compared with a range of widely renewable softwoods in Britain and Europe, and it emerged second only to Parana pine (*Araucaria angustifolia*).

Contrary to some beliefs, fast growth does not adversely affect the machining properties of pine. Good results can be obtained with all types of hand and machine tools.

Comparison with Asian species



General performance ratings

1-Very poor 2-Poor 3-Average 4-Good 5-Excellent	Turning	Planing	Moulding	Boring	Mortising	Cross-cutting	Routing	Finger-jointing	Hardness	Nail holding	Nail splitting	Stability	Sanding	Staining
New Zealand radiata pine														
corewood	4	4	5	4	1	4	3	4	2	2	5	3	5	4
outerwood	5	5	5	4	2	3	4	5	2	2	4	3	4	3
Douglas fir	4	4	4	3	4	5	4	4	2	2	4	3	4	3
Loblolly pine	1	4	4	3	3	2	1	3	3	2	3	-	2	3
Light red meranti	4	3	5	3	4	4	2	5	2	2	5	3	5	5
Dark red meranti	4	4	5	4	4	4	2	4	2	3	5	3	5	5
Parana pine	5	5	5	5	2	4	5	3	2	2	4	2	5	5
Mid-Swedish redwood	-	4	4	5	4	3	2	-	2	2	4	2	3	3
North-Swedish redwood	5	3	5	4	4	3	4	5	2	2	3	2	3	3
Siberian redwood	3	2	4	4	4	3	4	4	2	2	5	2	3	3
Swedish whitewood	2	2	4	4	1	2	2	4	2	2	4	2	3	4
Archangel whitewood	3	2	4	3	3	2	3	3	1	2	4	2	3	4
Western hemlock	1	4	4	3	3	3	3	4	2	3	3	2	4	3

Source: Scion

RENEWABLE AND SUSTAINABLE FOREST RESOURCE

New Zealand is acknowledged as one of the world's leading suppliers of high-quality pine. It also has the most advanced technology for clear-wood production. All 1.8 million hectares of New Zealand's plantations are renewable and nearly half are Forest Stewardship Council (FSC) certified. New Zealand's pine forests are highly productive and expanding – a rarity on the global scene.



New Zealand pine has been developed and refined by foresters and scientists as the world's most versatile wood. This has been achieved by combining outstanding skills in research and development, forest management, harvesting and processing.

The even texture and moderate density of New Zealand pine, combined with its ease of processing, make it one of the most attractive and versatile industrial wood species.

New Zealand pine plantations produce logs of excellent quality in just 25 years and, importantly, there is a continuing, sustainable supply of premium-quality wood for international markets.

The plantation solution

New Zealand is one of very few countries in the world with the certain ability to increase and sustain its total wood production. This is in contrast to the global situation, where harvesting rates are acknowledged as unsustainable.

New Zealand's large, high-quality plantation resource is continuing to increase the amount of wood produced annually.

Wood is a vital world commodity. On a global scale, nearly 3.4 billion tonnes of wood are consumed annually, and average wood demand increases by three tonnes every second, or nearly 100 million tonnes a year! Much of that wood is harvested unsustainably and illegally. Highly productive, sustainably managed plantation forests are part of the solution to that issue.

New Zealand has just 0.05% of the world's forest resource but is able to supply nearly 9% of the Asia-Pacific region's forest products trade.

New Zealand pine is sustainable, environmentally friendly, energy efficient and a cost-effective alternative to threatened native and tropical forests.



Origin of the species

New Zealand pine has been developed from the Monterey pine, a coniferous tree that occurs naturally in a few small stands on the Californian coast, and is related to the bishop pine (*Pinus muricata*) and knobcone pine (*Pinus attenuata*).

Pinus radiata is now the world's most widely established plantation softwood species (nearly four million hectares) and grows best in New Zealand, where conditions are most favourable. New Zealand's warm day temperatures, cool nights, fertile soil and a high, evenly distributed rainfall are ideal for producing fast-growing trees that produce high-quality wood.

In a well managed plantation, New Zealand pine will grow up to eight times faster than managed natural forests. In 30 years, one hectare can produce as much quality wood as 10 hectares of tropical forest in South-East Asia, or 40 hectares of Amazon forest.

New Zealand's experience in growing pine extends for generations of tree crops. This expertise in forest management is internationally recognised. New Zealand's intensive silviculture techniques guarantee consistent wood quality.

Extensive research into growth characteristics, forest health, management, harvesting techniques, wood performance and new products keeps the industry in the front line of global softwood producers.

Five special features

1. Natural

New Zealand pine wood products are created by selective sawing and processing, with low manufacturing energy inputs. The result is a natural wood product from a renewable resource.

2. Sustainable

New Zealand pine is an expanding resource, maturing at a rate that provides an increasing volume for the future. The continuing establishment of new forests provides long-term security of supply.

3. Well managed

A major programme of genetic improvement and advanced forest management expertise produces a wood resource with superior yield and desirable characteristics.

4. Strong

The strength of New Zealand pine compares favourably with that of most traditional construction lumber species. Appropriate conversion processes ensure that the higher-strength wood fibre near the outside of the log is sawn for structural applications.

5. Versatile

New Zealand pine is excellent for an impressive range of structural and appearance applications. It is easily kiln dried or chemically treated to produce stable and long-lasting products.

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Importantly, there is a
continuing, sustainable supply
of premium-quality wood
for international markets.

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Forest certification

The New Zealand Forest Industries Council defines certification as: verification that wood is harvested under conditions acceptable to a credible third-party certification system.

The main purpose of certification is to ensure that the harvest can be sustained by natural or human-induced regeneration. Certification also monitors the effect that forestry operations may have on local ecological, cultural and social structures.

Forest companies whose operations are “certified” as meeting certain fixed criteria can use the certifying agency’s brand on their timber when it goes to market.

Certification in New Zealand

Fifty New Zealand companies hold “chain of custody” certificates confirming that they have systems in place to track certified timber through their production lines.

In addition, a National Standard for Plantation Management in New Zealand, which has been extensively debated by forestry and environmental stakeholders, was released for public comment in November 2002. The objective is a certification framework for New Zealand forestry that will set an international benchmark for the sustainable management of forests.

The approach of the conservationist movement is typified by the FSC – backed by the WWF, the Sierra Club, etc. It promotes an approach to certification that uses continued market access to reward only the very best forest management – mimicking natural processes and preserving so-called “old growth”. The FSC group has a vision of a single, internationally harmonised system of certification requiring forest owners to comply with very high standards of forest performance.

The industry and forest owner groups see certification as a mechanism to promote progressive, step-wise improvement in forest management. They are led by the Programme for the Endorsement of Forest Certification schemes (PEFC) in Europe and the Sustainable Forestry Initiative (SFI) in North America. They support certification as a marketing tool to promote the environmental benefits of wood. These industry groups have a vision of an international framework of forest certification, based on mutual recognition of national certification schemes.

The objective is a certification framework for
New Zealand forestry that will set an international
benchmark for the sustainable management of forests.

Certification of tropical timber

Certification in the tropical forest industry has been slow. International Tropical Timber Organisation (ITTO) members say that is largely because of the inflexibility of standards that focus on end results rather than a “stepped” approach to sustainability. Tropical forests account for only around 8% of the world’s certified forest area.

Unique green partnerships

The basis of sustainable forestry development in New Zealand is a series of unique “Green Partnerships” between the forest industry and environmental groups. They are underpinned by two major agreements – the New Zealand Forest Accord and the Principles for Commercial Plantation Forest Management.

The signing of the Forest Accord in 1991 heralded an era of co-operation and consensus in the management of New Zealand’s substantial plantation forests. The benefits are apparent now in reduced conflict between environmental and commercial interests, and increased investment confidence. The Forest Accord recognises that New Zealand’s native forests should be preserved and that commercial plantations should produce most of the country’s industrial wood. It is a model that no other country has yet matched.

Signatory environmental groups also acknowledge the importance of plantation forestry as a means of providing wood products and energy on a sustainable basis. The companion Principles for Commercial Plantation Forest Management were developed in 1995 and signed by virtually the same members of the forest industry and environmental partners as signed the Accord. The



Principles for Commercial Plantation Forest Management were devised to deliver environmental excellence in plantation forest management.

National standard

Half the forests in New Zealand already have FSC certification and the goal is to have all forestry operations fully endorsed.

The national standard is an essential step in achieving the country’s goal of having its forestry operations fully endorsed by independent certification programmes such as those of the FSC.

The New Zealand model of forest management has evolved to meet local circumstances, where plantations of introduced tree species provide the industrial wood and native forests are more or less left alone.

New Zealand pine is differentiated from other timber around the world by New Zealand’s system of forest management. Certification is an important way of proving to the international marketplace that timber is produced sustainably in New Zealand.

PRUNING PRODUCES QUALITY CLEAR WOOD

Many of the trees in New Zealand's pine plantation forests are pruned while young to produce "clear wood" and restrict the knotty core to a small zone surrounding the pith of the tree. More than half of New Zealand's pine plantation forests are pruned three times in their first 10 years of life. That makes them unique, and the resulting clear wood highly prized.

Pruning regimes vary, but in general the first pruning is done when the trees are 5-6 metres (m) high. There are two more prunings before the trees reach 8 m - always leaving 3-4 m of crown so the tree can continue to photosynthesise effectively.

New Zealand pine trees grow upwards from their crown and outwards from both crown and stem. If a nail is hammered into the stem 5 m above ground level, it will remain at that height from the ground but will be progressively covered by new wood as the tree lays down more growth rings in its stem with each season. The same applies to the stubs of pruned branches. They stay at the same height and clear wood covers the stubs as the tree grows. The bark on the surface of the tree will show a pattern of "whorls" where the branches were pruned but there is excellent clear wood directly below. The defect "core" in the centre of the pruned log is narrow and well covered with high-value clear wood.





Logs and grades

The pine plantations of New Zealand are managed to produce predictable, premium-quality logs for a wide range of wood markets. This is possible because growing conditions are excellent and forest management techniques are among the world's best.

It is typical to harvest large (up to 80-centimetre [cm] diameter) logs in 30 years or less from New Zealand plantation forests. The logs are typically healthy with no insect attack, decay, internal splits or growth stresses.

Pine log grades cover a wide range, which means buyers can specify their preferred quality and match with the recommended range of uses. This is very important because there are significant quality variations between some log grades. Using timber from a lower-grade log for a higher-end application is likely to result in disappointment.

The quality of a pine log is determined by its size (diameter and length), shape (straightness and taper) and branching and wood property features.

New Zealand pine log grades and recommended uses

- **Pruned Peeler**
(High-quality, large, straight logs.) For sliced or peeled veneer, ply and decorative overlay veneers.
- **Industrial Peeler**
(Large, straight, un-pruned logs.) For knotty plywood grades and LVL.
- **Pruned Sawlog**
(Large, straight logs.) For clear and appearance-grade lumber, and industrial grades.
- **Small Branch Sawlog (S)**
For high-strength lumber.
- **Large Branch Sawlog (L)**
For temporary construction lumber, packaging and appearance components.
- **Long Inter-node Sawlogs**
(Wide branch clusters.) Ideal for recovery of clear wood furniture and joinery.
- **Posts and Poles**
(Small-medium, straight logs.) Low spiral grain, for engineering and ground contact; must be chemically treated.
- **Fibre and Pulp Logs**
Good but not matching any of the above classes - used for pulp, reconstituted and panel products.



LOG CONVERSION



LUMBER AND GRADES

New Zealand pine is a light-coloured, medium-density softwood with a moderately even texture that produces sawn lumber with excellent working properties.

Conversion

Logs for conversion are generally sound, with no decay, heart-shake or insect attack. New Zealand pine saws easily and high lumber recovery can be achieved, dependent primarily on saw pattern, log diameter and shape.

Freshly sawn lumber is prone to blue-stain and should be treated with a stain-control chemical directly after sawing, unless immediate kiln drying is intended. This is very important in warm and humid climates.

Sawn New Zealand pine dries easily and can be kiln dried rapidly from green. The wood can be readily treated with preservative to achieve all desired durability levels.

The diameter and shape (sweep, taper, ovality) of the logs do not usually limit the types of processing system that can be used. Sawing of logs is the most common processing method used. Peeling and slicing and the manufacture of a range of reconstituted wood products are increasing in importance.

Excellent results have been obtained with band saws, circular saws, frame saws and chipper canters in all the common sawmill configurations. Pine is similar to other medium-density softwoods in that more saw tooth side clearance (tooth set) is required than for hardwoods. A good surface finish can be achieved with appropriate feed speeds and sharp saws.

The full range of breakdown methods can be used with pine and the conversion levels achieved are dependent on the log and product mix and the efficiency of the sawmill. Cutting patterns are selected according to the machinery available, the log size and quality, and the products required.



Outerwood and corewood in New Zealand radiata pine

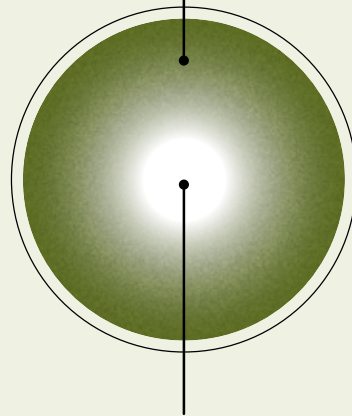
Mature wood

Properties:

- mainly sapwood
- higher density
- more stable
- fewer knots
- narrower growth rings

Uses:

- high-quality structural
- clear lengths for furniture
- decorative boards
- preservative-treated lumber



Juvenile wood

Properties:

- mainly heartwood
- lower density
- less stable
- many small intergrown knots
- wider growth rings around pith

Uses:

- industrial packaging
- decorative boards
- formwork
- knotty furniture
- low-strength structural
- reconstituted products

Conversion patterns

Most traditional conversion patterns can be used with pine, provided the quality zones are recognised.

• Grade sawing

Commonly applied to high-value pruned logs. Boards are removed around the log to maximise the recovery of high-value clear wood.

• Cant sawing

Commonly used to segregate the wood quality zones in un-pruned logs. The juvenile wood zone is isolated in the inner boards. Suitable for small and medium-sized logs.

• Live sawing

Used where only basic equipment is available or when wide boards are needed. This pattern allows recovery of some quarter-sawn boards.

• Peeling

Standard method for plywood and LVL production, used on pruned and industrial peeler grades.

Lumber grades

Through good silvicultural management, New Zealand pine logs come in a range of qualities capable of yielding lumber grades to meet almost any requirement.

Appearance grades (board grades)

For finishing and furniture uses, can either be clear of knots or contain minor blemishes and tight knots. These grades include:

- **Clear lumber**
Free of knots and blemishes, used for high-quality joinery, furniture and mouldings.
- **Cuttings grades**
For reprocessing to produce shorter clear lengths with excellent machining and gluing properties. These grades contain large knots and blemishes that are removed by cross-cutting and ripping. The resulting clear components are often finger-jointed and edge-glued to produce mouldings and furniture.

Structural grades (framing grades)

Used primarily for construction where strength and stiffness are important. The main factors influencing a structural grade are the size and location of knots. Grades limit such defects to meet specified strength requirements.

Industrial grades

Used in packaging for various products such as pallets, cable drums and concrete formwork. Grades contain a range of knot sizes compatible with the final use.

Industrial grades are also produced for export, including thinboard and a range of other grades to buyer specifications.



New Zealand timber producers are able to grade to most customer requirements. Common export grades include:

- **Australia**
Standards Association of Australia F5 and F7 structural grades (visual and machine stress graded).
- **United States**
Western Wood Products Association random width lumber specifications including mouldings and better, shop and factory grades.
- **Japan**
JAS structural grade specifications (which also include glue-laminated and plywood grades).

Grading rules and methods

Pine may be graded to any grading rules, but those that recognise its particular characteristics are generally the most effective. Rules that recognise the juvenile and mature wood properties of pine, and the improvements in structural properties that occur as distance from the centre of the log increases, are more effective than rules that make distinctions on the basis of growth rate as measured by ring width.

There are two commonly used grading methods available in New Zealand.

1. Visual grading

Where the incidence of visible characteristics is visually assessed by a trained grader. This method is used for appearance, structural and industrial grades and is the most commonly used.

Characteristics present in pine and that may be specified in visual grades include knots, bark and resin pockets, resin streaks, pith and associated juvenile wood zone, needle fleck (bird's eye), grain deviation and blue-stain.

Knots are the major characteristic encountered in pine that affect quality grade. The type, position and condition of knots vary considerably between grades.

In long-length appearance grades, encased knots (surrounded by bark) are more severely limited than inter-grown knots.

In strength grades, the type of knot is largely irrelevant because it is the size and position of the knot or group of knots (coupled with wood density) and the associated grain deviation that affect strength.

New Zealand pine saws easily, and high lumber recovery can be achieved.

2. Machine stress grading

Where the timber is passed through a machine that measures its bending stiffness and assigns a grade on the basis of predetermined relationships between strength and stiffness.

This method is used for structural grades. It is more precise than visual grading and therefore very reliable.

The grading rules used in most countries group species according to their structural properties and assign the same design values to all species in the group.

In Australia – pine is grouped with western hemlock, cypress pine, red meranti, loblolly pine, maritime pine and Australia-grown Douglas fir.

In Japan – pine is grouped with *Pinus merkussi*, Sumatran pine and those species in the spruce-pine-fur (SPF) classification used in the US and Canada.

In the UK – the strength classes assigned to pine are closest to those assigned to British-grown Corsican pine, Canadian SPF, European redwood/whitewood and Scots pine.

In North America – for decorative uses, pine compares well with ponderosa and yellow pines for the moulding and millwork markets.

Grade recoveries

Grades of lumber that can be recovered from pine logs are strongly influenced by the log quality. Variables that have most effect are: log diameter, sweep, inter-node length, branch size, knotty core size (in pruned logs) and wood density.

Branch size and spacing have an important effect on the recovery of visually graded lumber. As the branch size and/or number of branch whorls increase, the recovery of better grades decreases.

For machine stress grading, the most important factors affecting recovery are density and increased branch size.

It is useful to include a restriction on juvenile wood – which is found in the centre of the tree approximately 10 growth rings from the pith (the growth centre of the log) – in higher structural grades. This specific provision recognises that ring width limitations applied to other species are not appropriate to pine.

Limitations on knots and juvenile wood control 60% of the variation in lumber strength. The remaining variation is controlled by factors such as density and slope of grain, which are difficult to assess visually.

Machine stress grading, which measures stiffness, directly eliminates any concerns about ring width and low-density juvenile wood.

Mechanical properties of sawn timber

The mechanical properties of sawn timber are closely related to knot size and density. Because density increases with increasing distance from the centre of the log, mechanical properties also increase. Ring width generally decreases as distance from the centre of the log increases. Studies in Japan have shown that wood from pine forests that have been thinned some time before harvesting can have wide growth rings but good strength and stiffness.

In graded lumber, a ring width limitation has very little effect on the weaker pieces that govern design strength. New Zealand studies of structural timber graded to Japanese grading rules have shown that if the maximum ring width permitted in the grade is reduced from 20 mm to 6 mm, the recovery of nominal 100 x 50 mm timber drops by 50% while the design strength increases by only 10%.



PROTECTION IN TRANSIT

Sap stain, mould and decay fungi can cause serious financial losses in forest-based industries. This large and diverse group of fungi can infect freshly felled logs and sawn timber that often then need to be downgraded.



Freshly cut sapwood is particularly vulnerable to attack because its high moisture content (60% to 200%) and available supply of simple nutrients provide an excellent substrate for fungal growth.

All wood species vary in susceptibility to fungal attack; New Zealand pine is less susceptible than rubber wood, but more susceptible than Douglas fir.

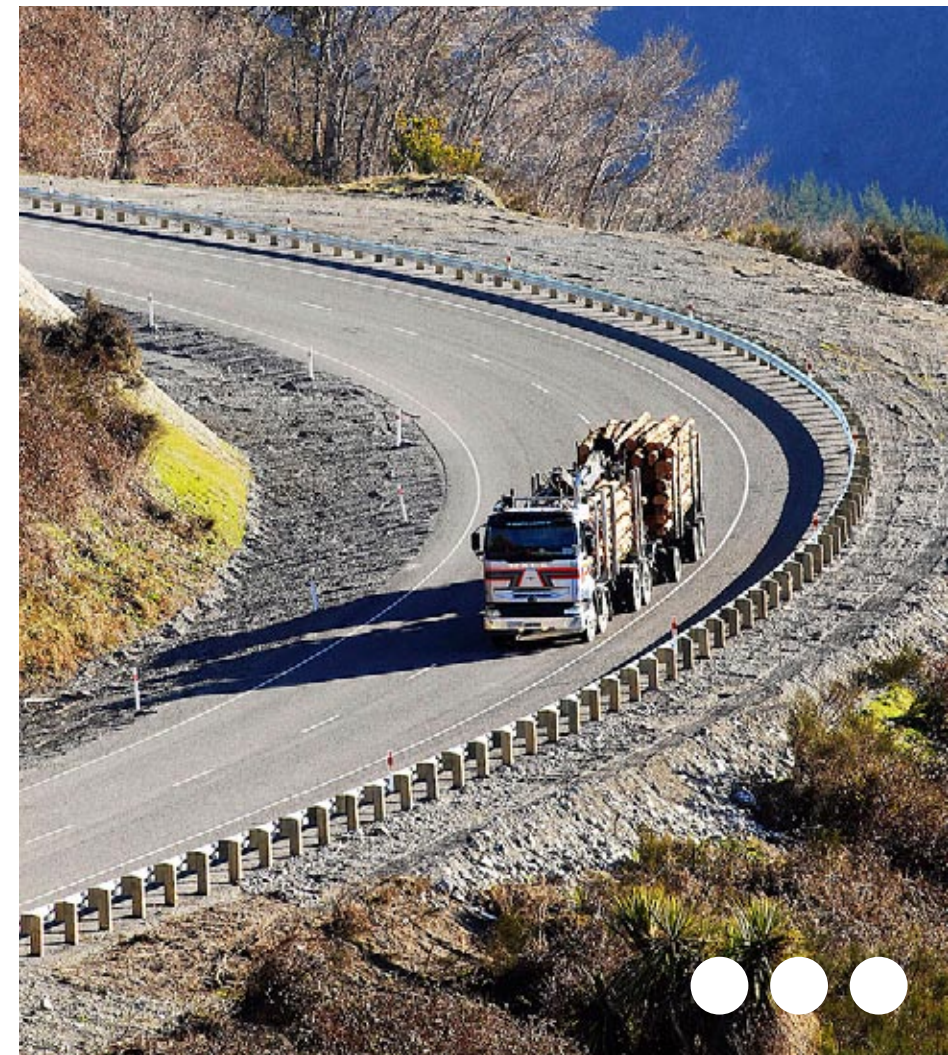
Chemical or physical control regimes can be used to prevent fungal attack. Chemical control (commonly known as “anti-sap stain treatment”) involves the application of fungicides to the surface of the timber. Anti-sap stain fungicides provide only temporary protection.

There are two methods of physical control: kiln drying sawn timber, and keeping moisture content above a level at which fungi can develop by sprinkling water or submerging. Kiln drying has the significant advantage that once wood is dry (provided correct handling practice is observed to prevent re-wetting) sap stain and other fungal attack are permanently prevented. Wetting (with sprinklers or submersion) is a temporary control measure and sap stain will occur if wood is allowed to dry out.

The choice of treatment depends primarily on market requirements. If a guarantee of sap stain-free wood is demanded and strict control of the time it takes to get the lumber to the customer cannot be achieved, kiln drying is the only satisfactory method.

Chemical control can be very reliable if lumber is delivered to the customer within an appropriate timeframe. The maximum period that sap stain can be prevented depends on factors such as climate and handling practices, and individual cases may require expert advice. In general, for sawn lumber the maximum period for which protection can be achieved is four months and for logs it is three months.

Effective control of sap stain depends not only on correct handling after treatment but on rapid processing before treatment. When conditions for the establishment of sap stain are optimal, it is necessary to process logs within one to three days. It is critical that anti-sap stain chemical is applied as soon as a fresh log is debarked or when lumber is cut from logs. Treating wood that is already infected will not prevent further fungal growth.



Protection of logs

If logs are to be protected against fungal degrade, they should be peeled and treated within one to three days of the trees being felled. It is important to get logs to the sawmill, and to process them, as promptly as possible. This is particularly true for imported logs, which will have been in transit for some time. Further storage should be avoided since any delays could cause a loss of wood quality. After six months from felling it is unlikely that any unblemished lumber will be produced.



Protection of sawn lumber

Kiln drying

If lumber is kiln dried and properly stored and handled to prevent re-wetting, it can be stored indefinitely without risk of fungal attack. When sap stain-free lumber is demanded and delivery to the customer within four months of tree felling cannot be guaranteed, kiln drying is the only satisfactory method of processing.

Anti-sap stain treatment

Sawn lumber must be cut from uninfected logs if anti-sap stain treatment is to be successful. Because machined lumber is less absorbent than sawn lumber, concentrations of anti-sap stain treatment must be higher for machined lumber than for sawn lumber.

Most anti-sap stain formulations are used as suspensions or emulsions rather than solutions. As such, they are prone to settling at the bottom of dip tanks and absorption onto sawdust or onto other contaminating material in treatment dip tanks. It is therefore essential that dip tanks be regularly agitated, kept free of extraneous materials and have excessive sawdust removed at frequent intervals.

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New Zealand pine is less susceptible than rubber wood, but more susceptible than Douglas fir.

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DRYING

The performance of any wood species used for the manufacture of high-quality products is greatly influenced by moisture content. It must be properly dried or it will shrink and distort, and New Zealand pine is no exception.

Pine is one of the easiest wood species to dry. It can be dried rapidly with little degrade if appropriate equipment is used. However, wood from close to the centre of the log (core wood) can tend to twist because of spiral grain. If the wood is correctly dried to the appropriate moisture content for the end use, and the end-use products are correctly installed, it will be stable in use.

A full range of drying methods can be used for pine, from air drying to high-temperature kiln drying.

Drying properties

The properties of pine that affect its drying can be summarised as follows.

New Zealand pine is predominantly sapwood of high moisture saturation (moisture content 100%–220%, depending on the density). The heartwood has a much lower moisture content (about 40%–50%) than the sapwood.

New Zealand pine sapwood is highly permeable and, therefore, capable of drying rapidly. Heartwood, although less permeable, has a lower initial moisture content and drying takes slightly less time than for sapwood. The high initial moisture content and rapid drying may cause difficulties where drying equipment has insufficient heating, airflow or venting capacity.

Wood from within the first 10 rings of growth (juvenile wood or core wood) presents a special warping problem as spiral grain can cause twist. High-temperature drying and stack weighting of 500–1000 kilograms per square metre (kg/m^2) of stack surface should be used to reduce the distortion of this material.

As with most species, the sapwood is prone to infection by fungi. Anti-sap stain treatment is essential for short-term protection against stain and mould. The risk of infection by decay fungi during air drying, especially with large-section lumber, must be minimised. Kiln drying, if carried out very soon after sawing, will avoid the need for anti-sap stain treatment. Dry lumber that is kept dry will not be infected by stain and mould fungi.

The use of water-borne preservatives and pressure-treatment processes to enhance the durability of New Zealand pine changes the drying properties of the wood markedly and re-drying after treatment is slower and more difficult and results in a greater variability of the final moisture content.

Drying practices

Air drying

The lumber stacks should be at least 300 mm above the ground, separated by 300–400 mm, and aligned parallel to the prevailing wind in order to promote rapid drying. Fillets (stickers) between boards should be of uniform thickness between 19 mm and 25 mm, evenly spaced along the length of the boards and vertically aligned within the stack.

Warping and surface checking are adequately controlled by good stacking, avoiding overhanging ends and using stack covers.

Low-temperature drying

This includes heat pump dryers and dehumidifiers.

Preliminary air drying down to 60% mc reduces the drying time, lessens the risk of mould and fungal stains and results in a more uniform final moisture content.

An airflow of at least 1.5 metres per second (m/s) is required. In order to avoid prolonged drying times with lumber green off the saw, the compressor size in heat pump dryers may need to be increased above that normally used to 0.5 kilowatts per cubic metre of lumber.

Relief of stresses within the boards is not possible with this drying method.

Conventional kiln drying

Design requirements associated with the higher operating temperatures of these dryers are an increase in the heat input rate, venting capacity and airflow and airflow reversal capability. These features are necessary to avoid slow and uneven drying.



An airflow of 3 m/s or higher is required. The recommended kiln schedules involve a single step with equilibrium moisture content (EMC) of 8–9% for untreated lumber or for lumber treated by boron.

Lumber preservative treated with copper-chrome-arsenate (CCA) requires a multi-stepped schedule.

When final moisture contents are to be lower than 12%, final wet-bulb depressions of 15–20°C should be used during the later stages of drying.

At the end of drying, it is essential that the lumber be given an effective final steam conditioning to relieve drying stresses and reduce the moisture content variation within and between pieces. Steaming should be done at 5°C above the final dry-bulb setting, with maximum possible relative humidity. Steaming time should be four hours per 25 mm thickness.

Accelerated conventional-temperature drying

Structural and furniture-grade lumber can be dried using these schedules.

The permeability of pine permits the use of higher temperatures and airflows to reduce drying time while maintaining quality. Successful drying can be achieved by:

- Heat up period two to four hours.
- Air flow at least 4.5 m/s.
- Final steam conditioning at 100°C, 100% relative humidity for two hours per 25 mm thickness.
- Stack weights 500 kilograms per metre.

If surface checking occurs, a milder, multi-stepped drying schedule should be used.

High-temperature drying

Most widths of 25mm and 50mm thick lumber can be dried at high temperatures with extremely rapid drying rates.

High-temperature drying of furniture-grade lumber on a day-to-day commercial basis requires the maintenance of a very high standard of kiln operation and is not generally recommended.

High-temperature drying is not recommended for sawn squares or pressure-treated lumber, unless it is to be used for construction purposes where the increased incidence of surface and internal checking may not be important.

Kiln construction must be of a high standard, with fan capacity sufficient to achieve a uniform airflow of at least 5 m/s through the load, and a heating system sufficient to reach operating temperature in two hours and maintain the drying conditions thereafter.

Increasing the air flow to 8 m/s will reduce drying times by 20%.

A final period of steam conditioning is essential to relieve drying stress and reduce the variability of final moisture content.

For successful conditioning, the lumber must first be allowed to cool to below 100°C, but conditioning must be started within 12 hours of completion of drying. It is important that fully saturated steam is used.

Careful kiln stacking is essential and top weights of at least 500 kg/m² are recommended to control warping in the top layers. Weights of 1000 kg/m² are essential for drying lumber that contains core wood. The weights should be left in place during conditioning and a 24-hour cooling period.

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Storage and handling

In common with most species of wood, dry New Zealand pine, especially at moisture levels below 15%, can rapidly pick up moisture from exposure to air. Exposure of dried lumber, in particular after kiln drying, must be minimised. This means that:

- Kiln stacks must be de-filleted (stickers removed) within 24 hours of completion of drying, then block-stacked (dead-stacked) and stored under cover.

Although it is possible to protect dried lumber by using tarpaulins, sheds are preferable as they are more effective at preventing rain wetting. Covers or sheds should be sufficiently airtight to minimise air exchange.

- If long storage periods are anticipated, individual packets of kiln-dried lumber should be wrapped in plastic.
- Careful handling (especially during transport) and storage (preferably in an air-conditioned building) of New Zealand pine that has been properly dried will minimise damage.
- High-value timber must always be protected by either covers or wrapping. Packets containing lumber of different lengths should be formed so that the short lengths are securely housed within the body of the packet.
- Where wire strapping is used, protective corner shields should be used to prevent the wire cutting into the timber.
- Adequate support should be provided to the timber packets to minimise any induced distortion or breakage.

Moisture measurement

There are two main methods of determining the moisture content of pine lumber:

1. The standard oven-drying method.
2. Use of electrical moisture meters.

The oven-drying method is quite accurate, provided the lumber has not been treated with organic solvents and is not highly resinous. One of the main disadvantages of this method is the length of time required for a result. Measurement by oven drying can be speeded up by using thin samples and a microwave oven.

Electrical resistance and capacitance moisture meters can be used for timber in the range of approximately 6–24% moisture content. Most meters are calibrated for one species and must be corrected for other species and treatments. The following correction figures for treated and untreated New Zealand pine are for resistance meters that are calibrated to the following standard resistance relationship:

8% - 5010 M

12% - 180 M

16% - 19 M

Moisture content targets

There are two main drying situations:

1. Final moisture content less than 19%, to minimise degrade from mould and fungi and provide some guarantee of stability for structural products.
2. Final moisture content in the range of 5–15%, depending on the EMC of the end-use situation.

When drying to below 19%, either air or kiln drying can be used. However, the low final moisture content (less than 15%) necessary for high-quality uses can be obtained only by kiln drying. The required final moisture content will depend on a number of factors, and appropriate standards should be consulted.

Recommended moisture content for New Zealand pine interior woodwork in intermittently heated buildings

Location	Average mc (%)
New Zealand	12
Australia	10
Korea	8
China	7
Japan - excluding Hokkaido	10-11
Japan - Hokkaido	13
Malaysia/Singapore (air-conditioned buildings)	12
United States	
West Coast	11
Nevada/Utah	6
Gulf/Southeast	11
Other states	8
Canada	
Vancouver	8
Montreal	5
Continental Europe	10
United Kingdom	11



PRESERVATIVE TREATMENTS

Effective preservation treatments have been developed to ensure New Zealand pine has excellent performance across a broad range of applications. As with most softwoods, New Zealand pine is not a naturally durable species and its use in New Zealand for structural purposes has gone hand in hand with the development of an efficient wood preservation industry.

Unlike many traditional softwoods of commerce, such as spruce, hemlock and Douglas fir, the sapwood of pine is very permeable to wood preservatives, particularly in the radial direction. Complete penetration of the sapwood is always achievable, resulting in very extensive service lives for commodity wood products such as small electric power or telecommunications transmission poles. Total penetration of preservatives is rarely achieved with other softwood species.

To a large degree, in-service exposure conditions dictate the types of preservative used to treat New Zealand pine.



Boron salts

Boron compounds are used in situations where the main hazard is insect attack (e.g. *Lyctus* and *Anobium* species) and where exposure conditions will not result in leaching the chemical out of the wood. Boron salts are also toxic to termites, although they are rarely used for treating lumber against termite attack.

Copper-chrome-arsenate (CCA)

CCA has universally been found to be a very effective wood preservative. It is very suitable for treatment of New Zealand pine that will be used in moderate- or high-decay hazard environments. Although solutions of CCA are highly toxic, complex chemical reactions occur once the solution is in the wood and firmly bind CCA to the wood, making it exceedingly resistant to washing out.

Processes have been developed to accelerate this fixation process in order to minimise or even eliminate the possibility of environmental contamination associated with the use of CCA. However, where environmental or health legislation has forced restrictions on lumber treated with CCA, there are alternative formulations that are ideally suited for treatment of New Zealand pine. These include ammoniacal copper quaternaries (ACQ), copper azoles, copper HDO, and copper dimethyldio-carbonate (DMDC).

Creosote

Creosote is used for treating railway cross-ties and electric power transmission poles. Creosote treatment of sawn New Zealand pine is particularly effective because deep penetration of the heartwood can be achieved.



Light organic solvent preservatives (LOSP)

LOSP are used for the treatment of fully machined components and fabricated commodities. Their main advantage is that, unlike water-borne preservatives, they cause no swelling of the wood during treatment and require no secondary air or kiln drying after treatment.

Preservative treatment processes

An important feature of New Zealand pine is that it can be treated easily. In New Zealand and around the world nearly all treatment is done with the Bethel (full cell or vacuum/pressure) process. This process involves applying a vacuum of -85 kilopascals (kPa) to the wood, flooding with preservative solution at this vacuum, then pumping solution into the wood at 1400 kPa. The treatment is complete only when the wood absorbs no more solution.

Not only is the sapwood of New Zealand pine easy to treat, but the relatively small amount of heartwood present can be treated too. Research has shown that penetration of preservative into heartwood is improved by high-temperature drying or by steam conditioning before treatment. In fact, complete preservative penetration in pine sapwood and heartwood can be achieved consistently. *Pinus radiata* may be unique in this respect.

Because New Zealand pine is so permeable to wood preservatives, treating processes can be readily developed in response to environmental and economic pressures associated with traditional processes. These include processes to treat partially seasoned wood, to accelerate CCA fixation and to reduce post-treatment drying costs and CCA preservative.

The future international importance of boron as a wood preservative, and the processes used to apply it, cannot be ignored. As well as giving insecticidal protection, boron treatment imparts some decay resistance to the treated wood.

Preservative treatment for specific end-use conditions

With hazard class specifications, the nature of the biodegradation risk (decay, wood-boring insects or termites) is first determined from the wood exposure conditions (e.g. indoors, protected from the weather, outdoors, in contact with the ground) and the preservative retention and penetration into the wood are varied to reduce the risk of biodegradation to an acceptable level.

In New Zealand, round wood (posts and poles), sawn lumber and plywood are treated to six different hazard class levels. Preservative treatment requirements are generally equivalent to or exceed those of other countries that have formal wood preservation standards.

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	Australia & New Zealand	America	Africa	Europe	Japan
Framing & flooring lumber	H1/H2	H1	H1	1	K1/K2
Sill plates or bottom plates	H2/H3	H3	H2	2	K2/K3
Windows, bargeboards & fascia boards	H3	H2	H3	3	K3
Decking, fence boards	H3	H3	H3	3	K3
Fence posts, garden edging & landscaping	H4	H4	H4	4	K4
Wood foundations, transmission poles	H5	H5	H5	4	K5
Marine piles, breakwaters	H6	H6	H6	5	

H1

Sawn lumber used in situations continuously protected from the weather. The purpose of preservative treatment is to protect against attack by wood-boring insects. Boron is the main preservative used and treatment complies with all relevant standards for insect protection.

H2

Sawn lumber and plywood used in interior situations where there is a slight risk of decay and a risk of termite attack. CCA and LOSP are the main preservatives used. Treatment to this hazard class is solely for timber and plywood that will be exported to Australia.

H3

Sawn lumber and plywood that will be used in exposed exterior situations but not in contact with the ground. CCA and LOSP are the main preservatives used.

H4

Sawn lumber, round wood and plywood used in ground contact in non-critical situations. CCA and creosote are used in New Zealand for wood in this category.

H5

Sawn lumber, round wood and plywood used in ground contact with extreme decay hazards or critical end uses require greater protection. Mainly for house foundation piles and electricity network transmission poles. CCA and creosote are approved for this use. Preservative retentions are 33% higher than those of Hazard Class H4.

H6

Sawn lumber and round wood used in a marine environment. Only CCA is used and the main New Zealand pine commodity treated is marine piles.





WORKING WITH NEW ZEALAND PINE



MACHINING

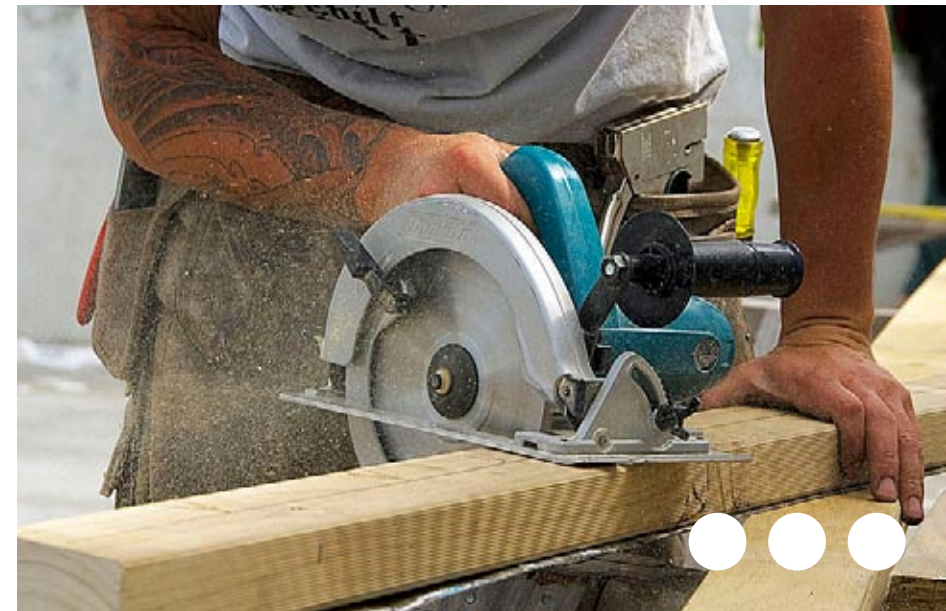
The superior machining properties of New Zealand pine are a result of its even texture and the relatively small differences in density between early wood and late wood. Ease of moulding, turning and planing is a strong feature. Tests have confirmed that New Zealand pine compares favourably with a variety of other internationally traded lumber.

Most wood products require machining in one form or another. The machining characteristics of any wood species can be as important as its strength, hardness or durability in deciding which species is best for a proposed end use. The most common form of machining is planing, closely followed by shaping and turning. Cross-cutting, boring, mortising and sanding are also common types of machining.

The average density of New Zealand pine is 350 kg/m³ in early wood and 550 kg/m³ in late wood, reflecting the comparatively even texture of the wood. This small variation in density within the growth ring and the gradual transition from early wood to late wood give New Zealand pine excellent machining, painting and staining properties.

Comprehensive tests to compare the machinability of New Zealand pine with other wood species have confirmed the ease of machining of both outer wood and juvenile wood in planing and turning. It also compares favourably with other softwood species in routing, finger-jointing, sanding and fastening characteristics.

As with all wood species, care must be taken in planing to ensure that planer knives are kept sharp, especially when dealing with knotty material. Dry, short-grained lumber may be planed successfully at 100 m per minute using medium cutting angles (around 20°). Accumulation of wood resin on planer knives is not normally a problem, but when it does occur, it can be handled by regular cleaning of the knives with a suitable solvent.



Comparison with other species

A comparative study of New Zealand pine and North American timbers was carried out by the New Zealand Forest Research Institute (now Scion) in collaboration with the University of California, Berkeley.

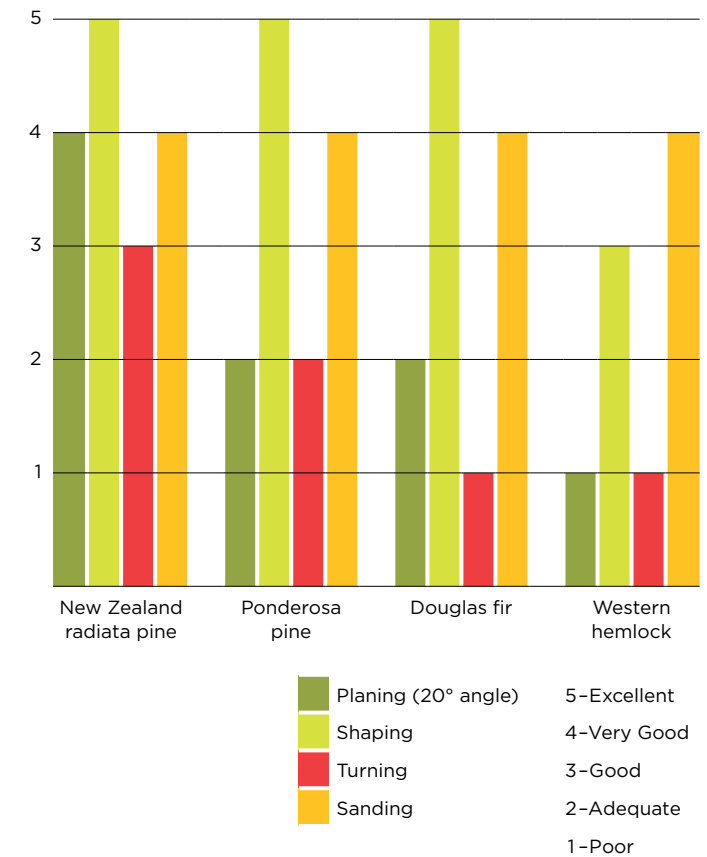
Pine and 13 North American timbers were tested to assess the suitability for panelling, mouldings, joinery and furniture manufacture. Fourteen criteria were used to rate each species, including planing, shaping, turning, sanding and gluing.

The quality of primary machining is critical to the manufacture of high-value products. While most finishes require sanding, the severity and type of defect resulting from primary machining will affect the cost, time and effort required to bring the product to an acceptable finish.

New Zealand pine's performance confirms its suitability for a broad range of uses. Its fast growth does not adversely affect its working properties and good results can be obtained with all types of hand and machine tool. Further details of this study are available from the New Zealand Ministry of Agriculture and Forestry.

Studies comparing pine with English and European species were also carried out and confirmed by the Buckinghamshire College of Higher Education in England.

Comparative machining results



GLUING

New lamination and finger-jointing technologies are increasing the use of New Zealand pine in a wide range of products – from small mouldings to huge engineered beams.

New Zealand pine can be glued with many types of adhesive, provided that care is taken to establish correct process control that allows for wood properties, adhesive formulation and pressing and curing variables. New Zealand pine is being glued and used extensively in a range of wood products, from structural uses to high-value furniture and interior fittings.

Adhesive types

Many different types of adhesive have been used successfully across a wide range of glued products, including furniture, joinery, wood panels, overlaid laminates, finger-jointed lumber for interior and exterior use and structural laminated lumber. Care should be taken to select adhesives appropriate to the production process and the colour of the end product, and also for their ability to withstand both end use and changes in environmental conditions during transport. If preservation treatment is required, the adhesive should be compatible with the chosen form of treatment.

Preservative treatment

Glue-laminated products treated with appropriate preservatives (either before or after gluing) have very high resistance to decay – for example, a bridge in New Zealand made from CCA-treated, glue-laminated pine has given good service since 1961. Preservative treatment of lumber after the gluing operation is commonly undertaken, particularly when using LOSP systems.

Wood preparation

Standard practices for gluing softwoods should be observed when gluing pine. Its high permeability aids curing by allowing solvents to move out of the glue line. However, the wood will absorb moisture very quickly when dry, which is a significant difference from the hardwood species with which many manufacturers are more familiar. It is important that glue mixes are not too low in viscosity, otherwise the glue may migrate away from the joint. Likewise, standing times between applying the glue and pressing for cure should be shorter for New Zealand pine than for hardwoods.

There are no known chemical problems gluing pine because it has a low extractives content. With most adhesives, a wood moisture content of 10–16% is acceptable. For products where the glue is to be radio-frequency



cured, moisture content must not exceed 15%. Care should be taken to ensure that the moisture content of the glued wood product is comparable with the EMC of the environment in which the wood product is to be used.

The temperature of the wood must not be too low while gluing, as some adhesives can be deactivated by cold, while others will not cure rapidly enough. Surface preparation by planing is the most effective method of obtaining a clean, flat surface for gluing. Owing to surface degradation and oxidation with time, surfacing should be carried out as close to gluing as possible, with 24 hours considered a maximum time for preservative-treated lumber and 72 hours for untreated lumber.

Finger-jointing

New Zealand pine compares favourably with other softwood species for producing finger-jointed products. It machines well, producing smooth, clean cuts with a minimum of crushing or splintering at the cut surface or glue face. High production rates can be achieved and wear on machine cutter knives is low. New Zealand pine's good machining qualities and uniform colour have led to its increasing acceptance for finger-jointing.

Finger-joint types

New Zealand pine can be jointed using either the face-to-face (vertical or European joint) or the edge-to-edge (horizontal or North American joint) machine types.

The horizontal joint, where the fingers are oriented so that they can be seen on the edge or side of the board, is generally preferred in North American markets for moulding and millwork operations, and the vertically milled joint for structural applications.

The structural joints for New Zealand pine use finger lengths of 10–25 mm, although shorter finger lengths of 10 mm are preferred. Adhesives used in structural jointing, such as phenol resorcinol and melamine urea-based glues, must meet strict exterior and exposure tests.

Finger-jointed product types

Finger-jointed products supply two main market segments. Structural wood products are produced with the joints designed to have high tensile strengths. Finger-jointing provides a greater degree of stability than single, large-dimension lumber pieces that can, in certain circumstances, be prone to distortion.

Finger-jointed New Zealand pine meets the requirements of New Zealand, Australian, Japanese, US and UK structural testing standards. Extensive qualification to recognised national standards and in-house quality control tests are conducted by finger-jointed product manufacturers to verify the ongoing strength and reliability of the timber joints.

Finger-jointed lumber is used for a wide range of products where appearance is important. For this end use, the 4 mm micro joint is offered by New Zealand manufacturers for New Zealand and Australian markets as it is easily jointed, provides a high-quality finish and results in higher timber yields.

When clear adhesives are used, unblemished lengths of finger-jointed timber can be produced for high-value end uses. Appearance-grade finger-jointed products include mouldings, fascia boards, handrails, balustrades, door and window components and weatherboard cladding.



Laminating

The ease of gluing New Zealand pine has helped to open many market opportunities for glue-laminated products.

Product types

Structural uses: New Zealand pine has been used in structural building applications for nearly four decades in New Zealand and Australia. It has demonstrated excellent performance in service. Laminated products are finding increasing acceptance in markets such as Japan and Hong Kong. New Zealand-designed and -fabricated wood structures have been erected in Africa, Hong Kong, Spain and throughout the Pacific.

Edge-glued panels: More rapid production techniques, such as clamp carriers and radio-frequency presses, are commonly used to produce high-quality edge-glued panels. By selecting the correct adhesive, the resulting product is light coloured with colourless glue lines. The panels are used in products ranging from fine furniture to intricately routed decorative panels. The light colour and product quality have helped to secure markets in Japan and Korea, as well as local use.

Face-glued products

The successful face laminating of New Zealand pine to produce posts, squares, rails and many other interior fittings has resulted in increased volumes being used in traditional Asian homes. Most of these products are non-structural and used mainly for decorative purposes. New Zealand pine is well suited for this application with its light colour and ease of gluing.

Laminated New Zealand pine is moulded and used as handrails in both interior and exterior applications.



Lamination processes

Successful gluing depends on the full control of each variable in the process. Variables such as moisture content, climatic conditions, mix formulation, adhesive spread, standing times and method of curing (ambient temperature, hot press or radio-frequency cure) are specific to each glue type and often specific to individual manufacturing operations. Minimising the time taken between surfacing and gluing can be very important for some adhesive systems.

Fillers such as nut shell flour and extenders such as wheat flour can be used (with advice from glue suppliers) to control mix viscosity and moisture flow during cure. Glue-line pressure during curing of a joint in solid New Zealand pine should be 700 kPa.

The press system to be used will depend largely on the adhesive and its nature of cure under ambient or accelerated conditions.

For a specific product, careful trials and consultation with an adhesive supplier should establish the base variables. Ongoing quality control is then needed to ensure that good bonds continue to be made.

Glued and laminated timber products with high strength, durability and quality finish can be obtained by selecting the correct adhesive type and preservative treatment for the desired end use.

FINISHING

The even texture and relatively small density variations across the grain in New Zealand pine provide excellent finishing properties, uniform acceptance of decorative stains and good paint retention. The benefits of applying surface coating to pine will vary according to the end use.

Exterior usage benefits

Surface deterioration is greatly decreased, particularly discolouration and loosening of surface fibres from the combined effect of rain, wind, sun and grey or black staining mould fungi.

The wood will be protected from excessive checking and dimensional change caused by swelling/drying resulting from seasonal climate change caused by water entry.

Interior usage benefits

The natural grain appearance will be enhanced. Chemical, heat and wearing resistance will be increased.

The in-service product will be protected from excessive dimensional change caused by swelling/drying resulting from seasonal climate variations.

Exterior situations

New Zealand pine is not naturally durable in exterior situations and should be preservative treated to the appropriate decay rating, as detailed elsewhere in this publication.



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New Zealand pine is an extremely versatile wood and is tolerant of the many available stains.

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Where the wood is well painted and generally protected from direct wetting, preservation to a low decay hazard rating may be used. Surface coatings can retard the rate of change of moisture content and, therefore, can reduce fluctuations in product dimension. The performance depends on the type of coating. For example, paints are more impermeable to water vapour than stains and oil-based paints more impermeable than water-based paints.

Paint systems are either solvent based (e.g. alkyd) or water based (e.g. acrylic). Although exterior alkyd paints provide wide variation in gloss and the paint film may be more impermeable to water, modern adhesion-promoting acrylic paints are superior on New Zealand pine for exterior uses. Acrylic paint films are permanently flexible, expanding and contracting with dimensional changes in the wood. As a result, acrylic has a better long-term waterproofing ability than alkyd paints that are more liable to become brittle and cracked with age.

Interior situations

For interior applications, New Zealand pine is very suitable for appearance-grade products such as furniture, components, joinery and mouldings.

Preparation for finishing

Good preparation is essential for the effective and attractive staining and coating of all wood. Desired surface characteristics are:

- Finely-sanded (150 grit at least).
- Defects smoothed over with fillers.
- Sharp edges and corners rounded.
- Dust, dirt and water free.

Staining

New Zealand pine is an extremely versatile wood and is tolerant of the many available stains. This allows it to be stained to look like other species, with colour matching being particularly effective. Water-based stain systems can also be effective on pine, although solvent-based systems avoid grain raising.

Coatings

Four coating types have traditionally been used on New Zealand pine furniture - nitrocellulose, pre-catalysed and acid-catalysed resin systems and two-pack polyurethanes. In New Zealand, pre-catalysed and acid-catalysed coatings are most widely used.

Environmentally friendly coatings

Low-volatility organic compound (low-VOC) coatings have gained favour owing to environmental concerns. In Europe and North America, the move has been toward low-VOC and low-formaldehyde coating types. Consequently, in those markets, nitrocellulose, pre-catalysed and acid catalysed coatings' use is down, while polyurethane (isocyanate control is possible through automated finishing lines), water-based and ultraviolet-cure coatings' use has increased.

MOULDINGS AND MILLWORK

International demand for New Zealand pine mouldings, cut stock and millwork has increased substantially over the past few years.



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Most of New Zealand's forest owners prune their pine plantations and have done so for decades. As a result, a high percentage of the New Zealand pine harvest produces premium-quality butt logs of clear wood. This resource is the foundation of one of the fastest-growing wood processing sectors in New Zealand – remanufacturing.

Typical remanufactured wood products include mouldings (shaped lengths for interior and exterior trim), cut stock (clear, solid wood and finger-jointed components) and millwork (doors and windows, porch-work, stairways, mantels, panel work, interior trim).

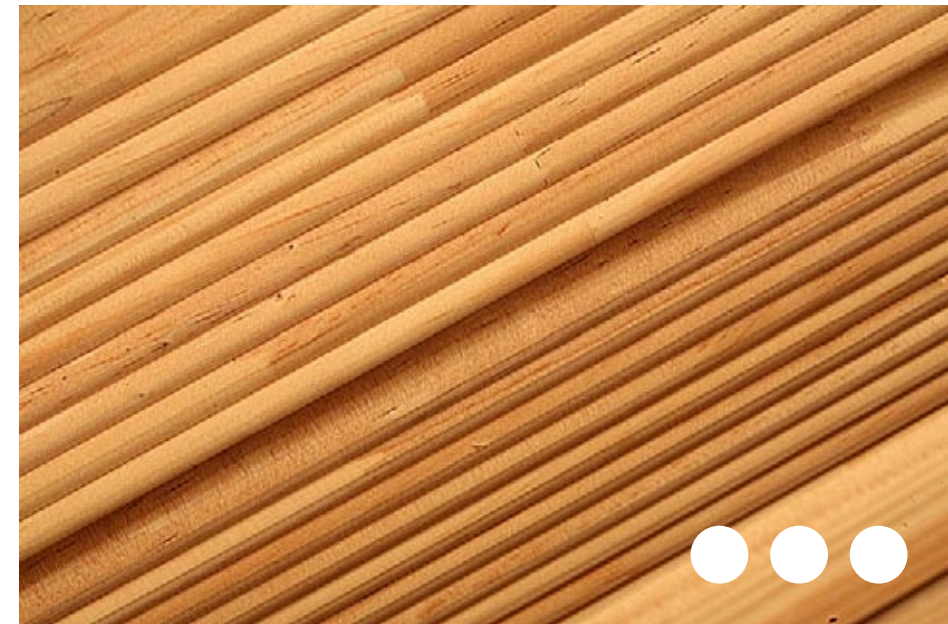
Markets for clear wood are expanding rapidly – nowhere more so than in the US, where New Zealand pine clear mouldings have overtaken ponderosa as the preferred species. Growth prospects are very promising in Australia, Japan, the Middle East, the European Union and throughout Asia.

Machining quality is critical to the production of high-value manufactured wood products. It is certainly as important as strength, hardness and durability. Comprehensive independent tests show that New Zealand pine has machining properties (cross-cutting, turning, boring, mortising and sanding) equal to or better than those of many of the internationally traded renewable timbers.

Remanufactured New Zealand pine is favoured for the uniform density that gives it excellent machining, painting and staining properties.

Unlike many other timbers, New Zealand pine is split resistant and can be easily nailed, screwed, connected and glued with consistently excellent results. Dimensional stability is very important for interior fittings and joinery uses. New Zealand pine has low shrinkage when dry, but customers must realise that the core wood contains spiral grain so should not be used where stability is vital to performance, as it is likely to twist.

The dimensional performance of New Zealand pine can be improved by finger-jointing or lamination.



FURNITURE AND COMPONENTS

The increasing availability of plantation-grown New Zealand pine has enabled the New Zealand forest industry to expand its production of semi-processed and fully finished products for export.

The remanufacturing sector is now a vital part of the industry, with products entering the markets of Asia, North America and Europe. The availability of pine as a sustainable and renewable resource makes it an attractive and acceptable alternative to lumber species from the world's dwindling natural forests.

Wood properties

Comparative tests undertaken by Scion (formerly the New Zealand Forest Research Institute) in conjunction with universities in North America and England have shown conclusively that pine machining properties (e.g. planing, sanding, moulding, turning) compare very favourably with those of most internationally traded softwoods.

In addition it performs very well in gluing and finger-jointing because of the even density within growth rings, good permeability and low extractives content.

The full range of interior and exterior stains and oils can be applied to enhance the wood figure, and this can be followed by a clear finish. The absence of high concentrations of extractives prevents any incompatibility with finishes and eliminates the need for special primers.





As with all species, high-value pine products such as furniture should be manufactured from kiln-dried wood with a moisture content appropriate to the particular product and market (refer to the Drying section in this publication). Accurate drying is particularly important for furniture manufacture as it will avoid delayed shrinkage, warping and end splitting or opening of glue joints. Protection of raw wood to avoid moisture pick-up during manufacture is also important.

Performance enhancement

Pine's natural surface hardness is comparable with that of other medium-density softwoods but, after treatment with a process developed by Scion, its overall hardness can be increased to the level of hardwoods such as mahogany and oak.

The process developed by Scion consists of pressure impregnating New Zealand pine with a densifying non-toxic chemical that is then cured in a kiln. The hardened pine product has extremely good machining and gluing properties and excellent dimensional stability, and accepts stains and clear finishes evenly. It is ideal for high-wear uses such as furniture, flooring and cabinetry.

Furniture design

The performance characteristics and wood properties of New Zealand pine combine to provide a raw material easily adaptable to most furniture styles. Designers and manufacturers accept that its good technical properties and ease of finishing in natural or enhanced colours provide enormous flexibility in creating furniture styles.

Whereas pine has been quite acceptable for so-called "low-end" furniture for many years, manufacturers are now finding that demand in upper and middle segments of the furniture market is increasing. This has generally resulted from collective industry efforts such as exhibiting at offshore trade fairs and bringing leading Northern Hemisphere designers to New Zealand.

Components

In addition to demand for manufactured furniture, the demand for partly processed and fully processed components is increasing. These are all kiln dried in New Zealand and protected against moisture pick-up and in-transit damage.

A very large range of products includes blanks, edge-glued panels, clear and finger-jointed cut stock for further remanufacture, mouldings, stair parts, door and window parts, and furniture components for assembly.

New Zealand pine usage has increased with the rapid growth of the do-it-yourself market. The most commonly manufactured items include ready-to-assemble furniture for home and office, interior wall units (shelving, cupboards), entertainment centres, dining room furniture and computer desks. Customers can get immense satisfaction from assembling and finishing New Zealand pine furniture purchased in kitset form.

ENGINEERED WOOD PRODUCTS

A new age has dawned for the global wood products industry, with an increasing use of engineered wood products being driven by increased environmental pressure and demand for superior performance.

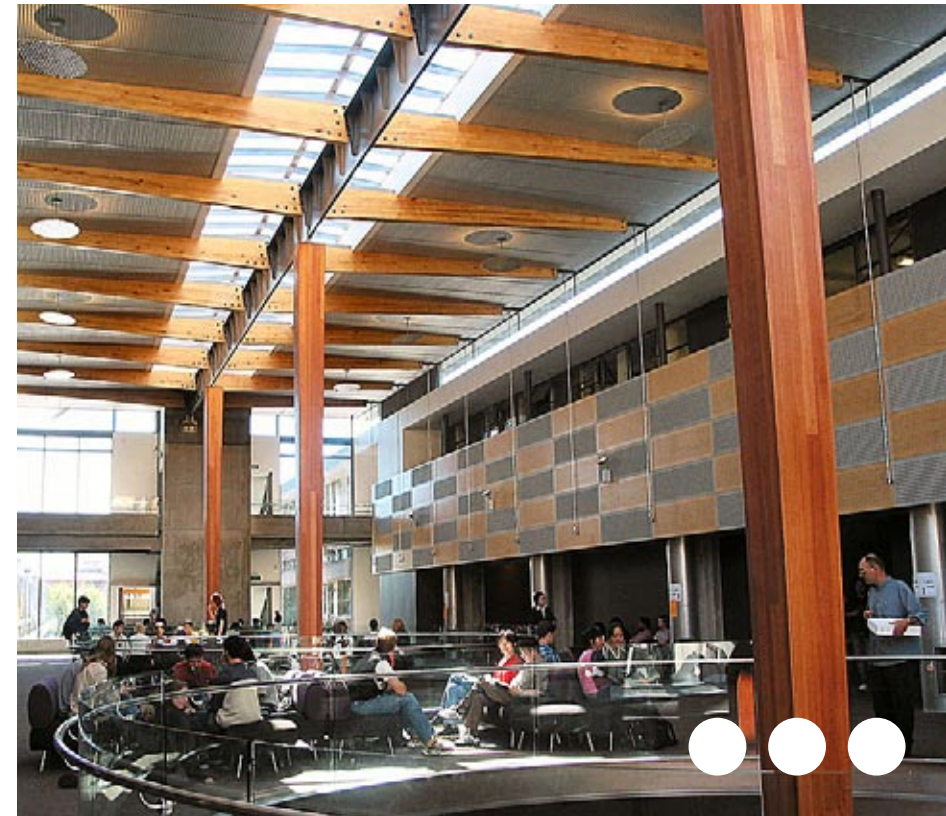
Engineered wood is manufactured by bonding together wood strands, veneers, lumber and other forms of wood fibre to produce a larger and integral composite unit that is stronger and stiffer than the sum of its parts. Typical engineered wood products include glulam timber, laminated veneer lumber (LVL), oriented strand board (OSB), wood beams, structural composite lumber and panels, and plywood.

New Zealand pine has excellent strength and is a very popular material for engineered wood products, including glulam timber and edge-glued panels, LVL I-beams, OSB and plywood.

New Zealand pine has excellent strength and is a proven performer across the full range of engineered wood applications. A major attraction of engineered wood is that it can be made from fast-growing and less expensive plantation wood species - easing the pressure on natural forests. It also uses more of the available resource and with almost no waste.

Engineered wood products compare favourably with non-wood products in terms of embodied energy, and emissions of carbon dioxide and other pollutants during manufacture. A bonus benefit, according to the US Engineered Wood Association, is that engineered wood improves on the inherent structural advantages of solid

wood. Cross-laminated plywood and OSB distribute along-the-grain strength in both panel axes. OSB eliminates knots and knot-holes, and glulam beams, LVL and wood I-joists can carry greater loads over longer spans than solid sawn wood of the same size.



New Zealand pine has excellent strength and is a proven performer across the full range of engineered wood applications.

Glulam passes the test

One of the longest-established and most versatile of the engineered wood products is glulam. It was developed in Switzerland in 1893 and some of the original structures built with it in Europe are still in service today, more than a century later.

Technically excellent and a highly versatile construction material, its end uses range from headers in residential buildings to major domes in sports stadiums seating more than 15,000 people. At the other end of the glulam spectrum are edge-glued panels – fashionable for dining and bedroom furniture, where the light colour of pine is favoured by consumers in some Asian markets.

Some say glulam is the most versatile and designer friendly of all the glue-engineered wood products. While architects and home builders favour straight beams, glulam can also be manufactured in a variety of curved shapes, which adds to its range and appeal.

Glulam bridges for pedestrians, motor vehicles and trains are used worldwide. One of the largest clear-span structures ever built, the Tacoma Dome in the US, spreads over 161.6 m.

Bright future for LVL

A continued increase in global demand for LVL is expected as the wood industry switches from large, old-growth trees to smaller logs from plantations and re-growth forests.

The North American pattern of replacing sawn timber with LVL in many structural applications is being mirrored to a smaller extent in Australia and New Zealand, where new LVL production capacity has been added by companies such as Carter Holt Harvey and Nelson Pine Industries.

Outside North America, the uptake of LVL has been most notable in Japan. The main areas of use are in semi-structural applications such as stair parts, wall studs and floor joists. New Zealand pine is most suitable for LVL manufacture and meets the JAS standard for structural use.

Proven applications include floor and roof structures, lintels, truss chords, scaffold planking, decking, manufactured housing, cross-arms, ridge beams, tension laminates, ladder stiles, purlins, girts, joists and furniture framing.



PLYWOOD AND LVL

The properties of New Zealand pine compare well with those of other species. It has excellent strength and can be used to make plywood that meets required national standards.

Plywood properties can be optimised by using differing veneer grades and selecting appropriate veneers according to the distribution of density within the tree. Japanese research has shown pine to be a favourable species for LVL.

Manufacture

New Zealand pine is uniform in density. The soft spring wood is more than half the density of the summer wood, whereas in Douglas fir the spring wood is much softer, only one-third of the density of the summer wood. This means that New Zealand pine is easier to peel for veneers than some other species.

Veneer should be dried to an average 5% mc before gluing. The gluing process needs careful control in the factory, according to site conditions and the type of adhesive. Daily records are necessary to identify changes in wood quality and climate in the factory for each product type. Plywood in New Zealand is manufactured to the joint Australian/New Zealand standard AS/NZS 2269.

Peeler logs

New Zealand pine has a low-density core zone in the centre of the log. This zone has a tendency to distort during drying. From about ring 10, the wood is of much higher density.

In plywood manufacture, the central core of the peeler log may be diverted to other uses. The density of the wood available for peeling is, therefore, better than the log average. When peeler lathes cut down to small cores, the veneer from the low-quality core should be separated out and used only in the inner plies of the panel. Veneer from the outer wood is of higher density and has greater strength.

Older trees have greater quantities of higher-density, higher-strength outer wood. A typical pruned log in the age range of current production has a knotty core of 18-26 cm, and diameters range from 35 cm to 75 cm at age 30 years.

Typical recoveries of dry veneer are 60-65% of under-bark log volume. The quantity of different grades varies according to log diameter, and for un-pruned logs it also depends on the branch sizes. Pruned logs may yield 15-50% clear veneer and 30-60% usable knotty grades. Un-pruned logs also yield good quantities of usable veneer. The quality of veneer recovered is related to branch size on the un-pruned tree. The smaller the branch size on the tree, the better will be the veneer recovered. Stand and mill surveys should be carried out to determine likely recoveries.

Strength of wood

The clear wood strength of pine compares well with that of other species traditionally used for making plywood. In many uses, plywood supports its load through its resistance to bending. Higher-density pine has a density and stiffness close to Douglas fir. For bracing and plywood web-beams, shear properties are important.

Different densities have different values for strength (modulus of rupture) and stiffness (modulus of elasticity). Veneers of New Zealand pine should be selected for density if these properties are important in the plywood. For many uses, high strength is not essential and lower density can be used.

Comparison of strength properties

Species Clear wood specimens, 2" (ATSM) basis	Specific Gravity	Modulus of Rupture (kg/cm ²)	Modulus of Elasticity (kg/cm ²)	Compression Strength (kg/cm ²)	Shear Strength (kg/cm ²)
Englemann spruce	0.35	650	91,000	310	85
Siberian larch	0.48	950	128,000	500	100
Douglas fir (coast)	0.48	870	137,000	520	80
Douglas fir (interior north)	0.48	920	125,000	490	99
Douglas fir (interior south)	0.46	840	105,000	440	106
Lauan		800	114,000	410	86
New Zealand pine (low-density sites)	0.43	870	101,000	380	102
New Zealand pine (med-density sites)	0.46	930	108,000	400	107
New Zealand pine (high-density sites)	0.50	1,000	117,000	440	115

Plywood standards

Pine has been accepted provisionally as a Group 2 species for use with US Product Standard PS1-83. With careful selection and grading, higher classification is possible. For Japan, plywood made with New Zealand pine veneer from high- or medium-density forests should have no problem meeting the requirements of JAS 1516.



Plywood strength

The bending strength of plywood is determined almost entirely by the veneers parallel to the span that are most distant from the neutral axis. These outer veneers carry almost all the load. This means that they determine the performance.

Faces and backs should be of high grades, such as clear high-density New Zealand pine or hardwood species. The inner veneers can be of much lower quality. If high strength properties perpendicular to the face grain are desired, the first cross-bands under the face veneer should also be of high quality.

Stability

The thickness and quality of the outer veneers are important for panel stability. If distortion-prone wood is used in a lower-quality core, internal stresses can be set up by moisture movement within the plywood. These stresses will distort the panel unless the face and back veneers are thick enough and of sufficient quality to resist the stresses. Thinner face veneers can lead to distortion problems but thicker, higher-quality outer veneers can help to increase the recovery of lower-quality veneer for use in the core.

Utilisation

New Zealand pine plywood is very easy to saw, shape and fabricate into a full range of structural components. Professor Motoaki Okuma of the University of Tokyo has tested pine, Lauan and Douglas fir plywood. Pine was found to have bending properties similar to the other species, but it had better shear properties.

New Zealand pine plywood is easy to nail and has good nail-holding power compared with Lauan plywood.

Shear strength of plywood is important in beams for bracing to resist winds or earthquakes. Knotty veneer has better shear strength than clear veneer and can be used in the core of panels.

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ADDRESSING ENGINEERING CONSISTENCY WITH LVL

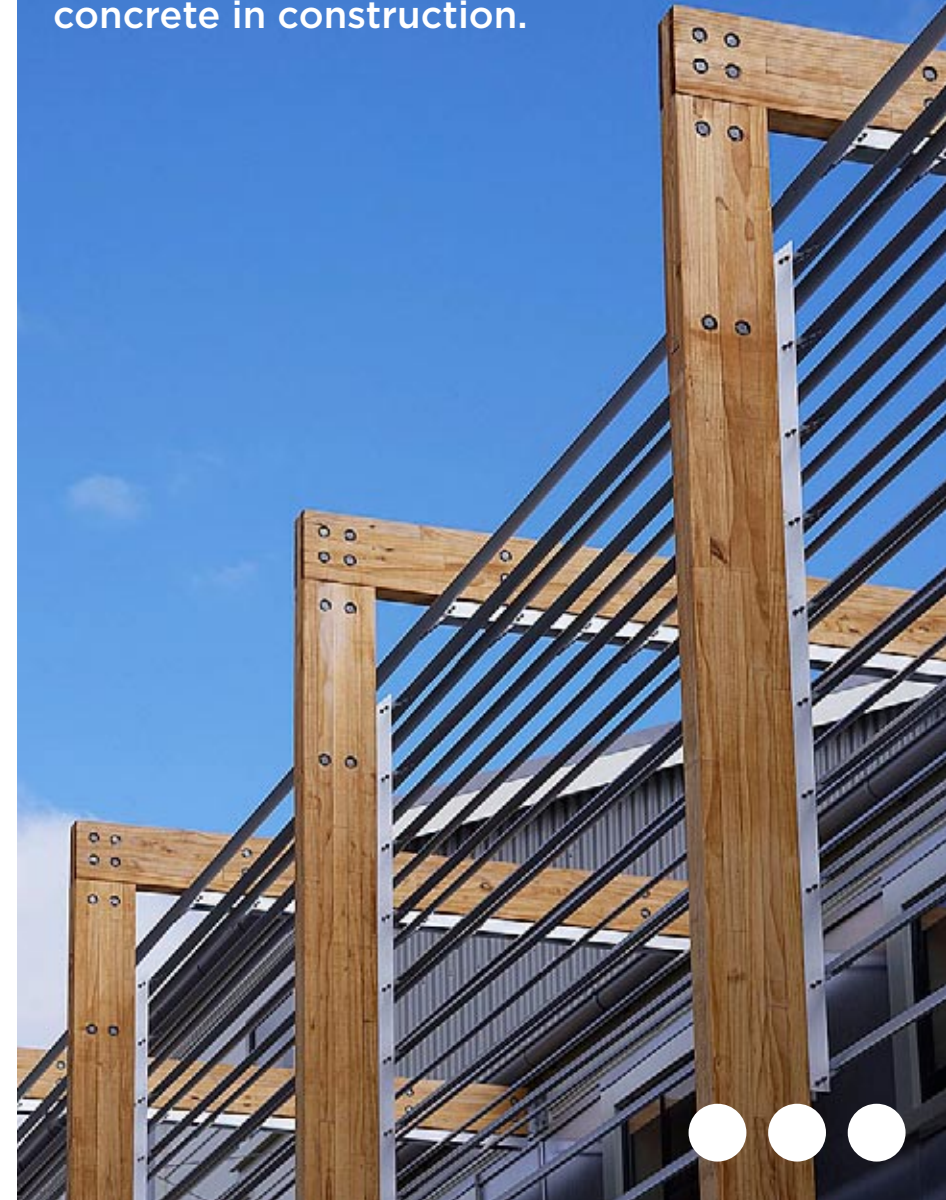
New Zealand pine has excellent strength but, as with all timber, its physical performance characteristics are naturally variable - both over time and along each length of sawn lumber.

Modern construction has come to rely on the proven and constant performance parameters of steel and concrete that allow engineers to provide reliable solutions in all kinds of applications at minimal cost. It is only comparatively recently that a wood-based structural material with similar consistency has become available. LVL manufactured from veneers of New Zealand pine provides the solution and offers consistent high strength and stiffness.

The product is manufactured from multiple thin veneers that are parallel laminated into long slabs that may be 100 mm thick, or even thicker. By using this laminating process, the varying physical properties of each individual veneer are “averaged out”, resulting in consistent performance.

The strength of LVL is approximately 1.3 times that of glulam and twice that of sawn timber. When it comes to bending, tension and compression, LVL is approximately 2.5 times as strong as solid timber.

LVL has the strength and stiffness to make it a viable and environmentally friendly alternative to steel and concrete in construction.

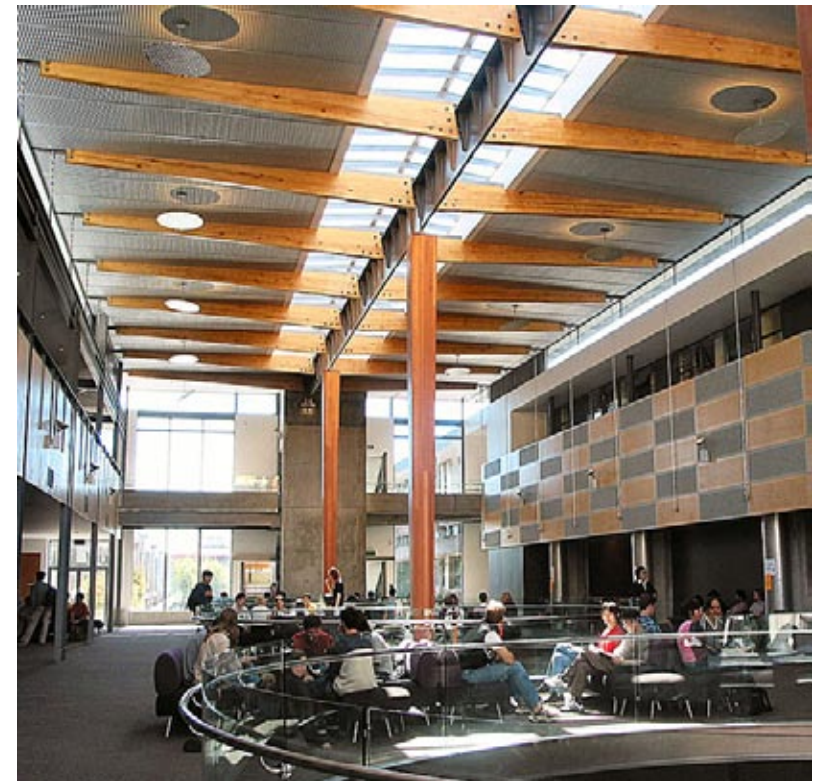


Manufacturing of LVL in New Zealand began in 2001 and capacity continues to increase as domestic and international demand grows.

At the Forestry and Forest Products Research Institute at Tsukuba, Japan, tests on LVL manufactured from many different species demonstrated that pine is very suitable for the product. In compression tests, pine LVL offered superior performance when compared with LVL made from other species. Manufacturing of LVL in New Zealand began in 2001 and capacity continues to increase as domestic and international demand grows.

Recognition of LVL's engineering consistency has increased the product's potential immensely. An added attraction is that it compares favourably with non-wood alternatives in terms of embodied energy and emissions of carbon dioxide and other pollutants during manufacture. In countries like the UK, where there is now a statutory requirement to produce a total "carbon budget" for all new structures, LVL is a highly attractive option.

One of the first significant markets for LVL was Japan, where it is popular for semi-structural applications such as stair parts and floor joists. The range of uses has expanded continuously to embrace most house construction elements, and now LVL is increasingly used for furniture framing.





WOOD BUILDING SOLUTIONS



CONSTRUCTION

New Zealand pine sawn lumber is a versatile structural building material well suited to the 2x4 building system. It is used equally successfully in larger buildings as glulam and for many other structural applications.

New Zealand pine is a preferred material for construction both as sawn lumber and as engineered products such as glulam, plywood and other panel products.

New Zealand pine's most attractive properties for construction usage are its medium density and uniform grain, which confer good fastening and working properties. New Zealand pine's strength and stiffness, ease of drying and suitability for treatment with preservatives and fire-retardant chemicals are also advantageous for construction. It is a relatively stable wood and kiln drying further improves its stability.

In common with other natural forest- or plantation-grown softwoods, grading of the sawn lumber is important in order to meet required structural properties. Ring widths can be large in comparison with natural forest lumber without compromising strength. For this reason, ring width is not a good indicator of strength properties compared with other grading criteria.

Wood frame construction

Pine is the preferred species for wood frame construction (the 2x4 system) in New Zealand and Australia. This system uses dimensioned timber of 35–45 mm thickness and widths up to 300 mm. The system is common in

North America and is finding increasing acceptance in the UK, Japan and other significant markets.

A particular advantage of the 2x4 system is the extensive load sharing that occurs between the individual framing members. This allows the use of lumber with relatively large defects (knots up to half the cross-section) because any weakness in one member will be compensated for by strength in an adjacent member. Another advantage is the lateral restraint provided to the framing members by the exterior claddings, interior linings, flooring and ceilings. This lateral restraint increases the strength of the completed structure.

Exterior claddings of wood-based materials, such as wooden weatherboards, wood-fibre cement boards and architecturally grooved plywood panels, are most common but masonry veneers of brick, natural stone or concrete blocks are also used with the 2x4 system. The suitability of New Zealand pine for house frames (as well as for finishing and joinery) has been well established. New Zealand is subject to high winds and earthquakes and the 2x4 wood framing system, using New Zealand pine backed up by a comprehensive set of building and lumber standards, has been proven to meet these demanding structural requirements well.

Studs

Pine is excellent for the vertical wall framing members called studs. Usually, a lower grade of lumber is used for the construction of non-load-bearing partitions.

Joists

The stiffest grades of pine are required for floor joists to minimise flexibility in floors under load. Kiln drying of joists is recommended before installation to minimise distortion, allowing accurate floor surfaces to be formed.

Rafters

Timber of an intermediate grade is appropriate for use as roof framing. It has moderate strength to resist wind uplift if lightweight roofing is used, or to resist high gravity loads imposed by tiled roofs. New Zealand pine's excellent fastening properties are advantageous too, enabling the roof to be constructed of trusses or framed in a more traditional manner.

Flooring

The composite materials of particleboard, plywood or medium density fibreboard (MDF) are commonly used with a clear coating or overlay. They have a cost advantage owing to the speed of construction and a practical advantage in that there are few joints.

Exterior and interior cladding

Finger-jointed, preservative-treated New Zealand pine can be used as exterior weatherboard cladding, provided it has a well maintained protective coating of paint or semi-transparent stain coating. Plywood panels machined to look like vertical boards also make an excellent cladding,



with the advantage that they require less maintenance than weatherboards. Feature interior finishings are also used in New Zealand construction.

Bracing

The best system of bracing in the 2x4 system is plywood cladding on all walls. Other methods are used, such as diagonal metal strap or angle members. These are nailed to the framing members at each end and wherever they cross a framing member. Interior sheet cladding such as fibre-reinforced gypsum plasterboard also adds considerable bracing to structures.

Sub-floor and foundations

Because pine can easily be treated to last permanently in ground contact, it is excellent for foundation piles and poles. Bearers are easily attached to the piles to support floor joists.

Post-and-beam construction

New Zealand pine is well suited for wood post and beam construction using a mix of sawn timbers for posts and engineered wood products for the beams and bracing.

Beams

Laminated pine makes excellent beams for this system. Such beams may contain many finger-joints in the laminations where defects have been removed to achieve the high strength and good appearance needed. High stiffness will be achieved if the laminations are selected by a grading machine.

Bracing

Diagonal bracing members in the post-and-beam system usually carry high loads when the building is subjected to earthquake or high wind conditions. Properly designed metal fastening systems are needed to transmit these loads through the framework. The excellent resistance of pine to splitting and shear forces means that such metal fastening systems perform well. A better method for providing bracing in this system is to use plywood nailed to the horizontal and vertical wall framing members.

Sills

Sill members are exposed to decay conditions because they are close to the ground and will become damp unless special moisture barriers are used. New Zealand pine, preservative treated to appropriate levels, will permanently withstand attack from insects and decay and provide the anchorage needed for the framing members attached to them.

Flooring

As for the 2x4 system, the most cost-effective type of flooring is particleboard or MDF.

Roof framing

The roof framing can be a trussed system of dimension lumber. If heavy framing members are used, glue-laminated members are appropriate.

Prefabricated building systems

There are many varieties of panelised prefabricated housing system in production. Kiln-dried New Zealand pine is excellent for these systems, which use a timber frame overlaid with sheet materials because it is dimensionally stable, adequately strong and stiff, and has good fastening characteristics.

Commercial and industrial premises

Multi-residential condominium developments up to five storeys have been built with the 2x4 system. Sound insulation in floors is achieved by using a lightweight concrete topping over a floor of plywood or particleboard. Fire protection and sound insulation between tenancies are achieved by building walls with staggered studs and multiple layers of gypsum plasterboard.

The success of New Zealand pine in housing is matched by its success in industrial building. Various structural forms using glulam lumber in the form of curved arches, portal frames or straight beams are used in larger industrial buildings.

New Zealand pine round wood treated with preservatives also has its place in house construction as foundation piles or pole frames, and in industrial pole buildings. Pole columns supporting glue-laminated beam rafters are a very efficient form of warehouse building.

In horticultural and agricultural uses, pine poles and sawn lumber play a vital role in crop support structures, stock fencing and yards, and agricultural buildings.



Built-up beams using plywood box construction have been made in spans up to 50 m. Other composite beams using metal webs and timber chords are recognised for use as long-span purlins.

Trusses assembled with toothed metal plates (gang nails) have come to dominate the domestic roofing market in many countries using the 2x4 building system, and New Zealand pine is commonly used in these trusses. In commercial structures, New Zealand pine trusses up to 30 m span are routine and even larger trusses have been built and used successfully.

Code acceptance

New Zealand pine is fully accepted as a structural lumber in the construction codes of New Zealand, Australia and the UK.

In Japan, it is included in the JAS 600 grading rules for structural lumber, in JAS 2054 for glulam and in JAS 1516 for plywood. It is acknowledged as a suitable construction material by Japan's Ministry of Construction.

Fastening properties

New Zealand pine's uniform texture gives better fastening properties than coarser-grained woods such as Douglas fir and larch. There is less difference between the density of the spring wood and summer wood bands within each growth ring. Thus, for a given average density, the spring wood bands in pine are of a higher density than those in coarser-grained species.

These higher-density spring wood bands give excellent resistance to splitting, so the lumber can be nailed at relatively close centres. This means that pine can be nailed green or dry.

Similarly, the lower-density summer wood bands, compared with coarser-grained species, make nailing and drilling easier. The uniform grain structure allows nails to drive true with very little tendency to follow the growth rings, as can happen in coarser-grained woods such as Douglas fir.

Other mechanical fasteners such as truss plates, nail plates and screws also perform well in New Zealand pine.

Uniform density and low extractives content ensure strong glued joints for both laminated and finger-jointed lumber. Glued joints may be made with preservative-treated lumber provided it is planed within a few hours of gluing.

Development of the GreenWeld process by Scion allows New Zealand pine to be glued when green to produce structural finger-joints that are as strong as joints made with dry lumber.

Development of the glulam timber portal frame, made with moment-resisting knee joints, has been successful in enabling industrial portal frame buildings in wood to compete with their steel or concrete equivalents. These knee joints have been made with nailed plywood or steel gusset plates and can develop the full strength of the members joined. Close spacing of nails possible with pine assists the efficiency of these joints.

The most recent development in jointing has been to fasten threaded steel rods into the timber with epoxy adhesive. An embedment depth of 10 times the threaded rod diameter is sufficient to develop the full strength of the steel. Joints with completely hidden steel bars can be made to give good appearance, good ductility and good fire resistance.

JOINERY AND INTERIOR FITTINGS

New Zealand pine is being successfully used for a wide range of interior fittings and fixtures, including windows, doors, frames and jambs, mouldings, stairs, cabinetry and bench tops.

All products are available in solid clear, as well as in finger-jointed and laminated forms. Knotty products are suitable as core for overlaying with veneer or other materials. Generally the knot structure of New Zealand pine is not suitable for “knotty pine” appearance products such as are traditionally produced from Scandinavian countries.

Texture and appearance

One of New Zealand pine’s unique properties is its uniform density. The even texture gives the timber its excellent machining, gluing, painting and staining properties.

Consisting mainly of creamy white sapwood with prominent fin resin canals, New Zealand pine presents a uniform appearance with little colour variation between pieces. This is an advantage for subsequent finishing.

Machining

Comprehensive tests to compare the machinability of New Zealand pine with that of other wood species have confirmed the ease of machining. It compares favourably with other softwood species in routing, finger-jointing, sanding and fastening characteristics.



Ease of moulding, turning and planing is a strong feature. New Zealand pine's fast growth does not adversely affect its working properties and good results can be obtained with all types of hand and machine tools. As with all wood species, care must be taken to ensure that cutting edges are kept sharp.

Fastening

Unlike many other timbers, New Zealand pine is split-resistant and can be easily nailed, screwed, connected and glued with consistently excellent results.

The low extractives content of New Zealand pine and its relatively uniform density allow above-average glued connections and joints such as finger-joints, dowels and mortise and tenon joints.

Finishing

The even texture and relatively small density variations across the grain in New Zealand pine provide excellent finishing properties, uniform acceptance of decorative stains and good paint retention. Good preparation is essential for effective and attractive staining and coating of all wood.

New Zealand pine accepts many available stains, which allows it to be stained to look like other species, with colour matching being particularly effective.

Dimensional stability

Dimensional stability is an important wood property for interior fittings and joinery uses. New Zealand pine has low shrinkage, which contributes to its stability.

However, stability is also affected by a number of properties other than shrinkage rates, including EMC, straightness of grain, spiral grain and permeability to gases and liquids.

Long-term movement is the property that best describes the dimension changes that occur when joinery is exposed to dry summer conditions and later to wet winter conditions. As a comparison, the dimensional response of cladding and joinery when exposed to fluctuating weather conditions, such as alternating rain wetting and sunshine, is best described as short-term movement.

Because of the presence of spiral grain, the core wood of New Zealand pine should not be used where stability is vital to performance.

Dimensional performance can be increased by use of finger-jointing or lamination. Such highly processed laminated, finger-jointed clear products are used widely in Japan where maximum stability is required, e.g. sliding door tracks (kamoi and shikii), mouldings and door frames.

Durability

Pine must be preservative treated for exterior uses. It is one of the most permeable wood species and can, therefore, be acceptably treated by pressure-impregnation, double-vacuum and simple-immersion methods. LOSP treatments are very successful for joinery.

INDUSTRIAL USE

New Zealand's first major export of plantation-grown New Zealand pine was to Japan for use as industrial wood. That was more than 30 years ago and the species has since become a first choice in many parts of Asia.



For a given density and grade, New Zealand pine is stronger but less stiff than several other species. This makes it very suitable for applications where shock loadings may occur.

Pallets

New Zealand pine has been used with great success in New Zealand and overseas for many years for the manufacture of pallets. Even without preservative treatment, reusable pallets made from New Zealand pine often have an economic life of more than five years.

Worldwide, more than half of all pallets are used by pallet “pools”. Many users agree that the performance of New Zealand pine pallets is comparable with that of American southern yellow pine pallets.

The performance of New Zealand pine when used for pallet construction is a function of wood density and lumber grade based on maximum allowable knot size. The design of the pallet is very important, as a poor design may reduce the usable life or cause failure in use. When pallets are stacked or stored in racks, failure can be dangerous and cause extensive damage.

The strength and stiffness of New Zealand pine vary depending on factors such as the latitude and altitude at which the trees were grown, silviculture and saw patterns used. For best results it is suggested that the lumber is kiln dried to a moisture content below 20% and either visually or machine graded. Suitable anti-sap stain chemicals can be applied to protect the light colour of the wood.

Wooden crates and boxes

A number of New Zealand sawmills specialise in sawing thinboards and framing for industrial packaging crate and box uses. This requires sawing to tolerances of 30.5 mm. As machinery sizes vary, sawmills are willing to cut lumber components to the sizes required by the crate manufacturers.

The performance of New Zealand pine for crate and box uses is again a function of wood density and lumber grade, based on maximum allowable knot size and moisture content. There is ongoing potential for both New Zealand pine timber and plywood in box and crate making, specifically in the one-way export sector.

Increasing use of computer-aided design for box and crate packaging makes New Zealand pine an attractive wood material because of the large amount of data available about the species, including its known strength characteristics.

Throughout the whole range of industrial packaging, New Zealand pine has a unique advantage in its very good nailing properties. Its ease of nailing, resistance to splitting and the holding properties of ring-shanked nails make it ideal for crates and boxes.

Cable drums

New Zealand pine accounts for much of the industrial lumber used for the manufacture of cable drums in Japan. Many New Zealand sawmills are equipped with facilities to saw industrial-grade squares for later resawing.

Knot size is not a limiting factor for drum sides, as the board thickness can be increased and double thicknesses used in load-sharing situations on large cable drums. Relative to steel and plastic drums, wood has the advantages of low cost, ease of repair, workability and flexibility in terms of the size of drums that can be made.

USEFUL WEB LINKS

NZ Wood
Promotional and development programme
www.nzwood.co.nz

New Zealand Pine Manufacturers' Association
Industry group
www.pine.net.nz

New Zealand Pine Exporting Companies
Industry group
www.nzpec.co.nz

Wood Processors' Association of New Zealand
Industry group
www.wpa.org.nz

Inwood
Timber industry information
www.inwoodmag.com

New Zealand Timber Industry Federation
Industry group
www.nztif.co.nz

Timber Design Australasia
Timber industry information
www.timberdesignmag.com

Scion
Research institute developing sustainable biomaterials
www.scionresearch.com

Foundation for Research, Science and Technology
Research funder on behalf of the New Zealand
Government
www.frst.govt.nz

Ministry of Agriculture and Forestry
www.maf.govt.nz

Ministry of Economic Development
www.med.govt.nz

Ministry of Foreign Affairs and Trade
www.mfat.govt.nz

New Zealand Forest Owners Association
Industry Group
www.nzfoa.org.nz



CASE STUDIES

BODYGUARD
WOOD
PRODUCTS

LOCKWOOD
GROUP

McINTOSH
TIMBER
LAMINATES

VERDA
NEW ZEALAND



BODYGUARD WOOD PRODUCTS



www.bodyguardwood.com

Bodyguard Wood Products is a joint venture between three New Zealand companies – Jenkin Timber, Pacific Timber and Taranaki Sawmills. It produces and markets a range of timber exterior wall cladding products for US homeowners and builders who prefer to use a natural product but want a durable solution.

Before the arrival of Bodyguard in the US, demand for durable natural wood cladding was not being adequately met and homeowners and builders were turning to composite products – plastics and ceramic blends – in order to get durability and the look of wood. Alternatively they were using untreated wood products, many of which are susceptible to rot within a period of three to five years after installation and offer no protection against insect attack. Bodyguard products are a viable alternative and became the first durable pine option in the US market.

The US market is characterised by diverse geography and regional trends and tastes, but there are some similarities to New Zealand's culture, housing designs and architectural tastes. The Bodyguard Wood Products joint venture was established so that the individual



The Bodyguard Wood Products joint venture was established so that the individual New Zealand companies involved could collectively achieve the required scale, capability and financial support to meet the needs of the US market.

New Zealand companies involved could collectively achieve the required scale, capability and financial support to meet the needs of the US market.

While a co-operative approach was unfamiliar territory for each of the companies involved, Bodyguard has been a success for its shareholders and suppliers because it has been well structured and carefully managed. By getting companies that are competitors in the domestic market to collaborate in supplying the US market, Bodyguard helps its suppliers to manage their capacity while simultaneously ensuring timely supply of a full range of products to the US.

California is the major US market for Bodyguard, and building supplies retail chain Home Depot stocks Bodyguard products in its Hawaii stores. The north-east region is also fertile ground for market expansion owing to the wet climate and the resulting decay issues that exist with the use of non-durable wood products.

Bodyguard products are supported by a 30-year limited warranty against decay and insect attack and include:

- Trim boards in a range of textures and standard sizes.

- Sidings in an extensive range and variety of profiles
- Exterior mouldings - both decorative and utility profiles.

The timber used to make Bodyguard's products is sourced from plantation forests sustainably grown in New Zealand. The products are FSC certified and environmentally friendly. Bodyguard products are protected with an azole-based Light Organic Solvent Preservative treatment system approved in the US by the Environmental Protection Agency.

The active ingredients used to treat Bodyguard products are a blend of fungicides, primarily used in food crop protection, and an insecticide common to household sprays and crop usage. Further enhancement is provided by the application of two coats of alkyd primer, offering protection against the elements during the construction process and ensuring a smooth, paint-ready finish. The treated wood is safe to handle using standard building site and woodworking safety practices.

LOCKWOOD GROUP



www.lockwood.co.nz

The innovations that distinguish the Lockwood Group's building system, structural integrity and ecological awareness from others are the result of more than 50 years of dedicated research, development and passion.



The innovative Lockwood building system was originally created in 1951 by Jo La Grouw Snr. The fundamental strengths of a Lockwood home cannot be copied; they are unique and exclusive to Lockwood.

Instead of being nailed, screwed, bolted or glued together, the walls in a Lockwood building are locked together using an intricately engineered aluminium profile that slots into specially machined grooves in solid laminated New Zealand pine.

Lockwood's patented system, combined with the use of vertical tie rods in the walls, is sturdy enough to resist earthquakes and typhoons all around the world. Independent testing has reported that owing to superior structural integrity, Lockwood buildings will emerge undamaged when subjected to earthquakes up to 7.5 on the Richter Scale and can withstand wind speeds of more than 185 kilometre per hour. Simultaneously, the Lockwood system has the flexibility to handle temperature extremes, from those of snowy Russia to the harsh desert climate of the Middle East.

Dedicated to being environmentally aware and socially responsible, Lockwood's passion for protecting the environment is long standing – it has been working with timber for more than 50 years. Because wood is Earth's most renewable raw material, using it is vital in the fight against climate change. The more wood used for building, the more carbon that is stored, and the more trees that are grown, the more oxygen is released into the atmosphere. Wood also takes less energy to produce and releases less carbon dioxide than other building materials (such as steel and concrete) during manufacture. It has been described as "the ultimate building material".

Now, Lockwood has taken its environmentally friendly philosophy a step further, with the revolutionary EcoSmart range. New Zealand “eco architect” Dave Strachan designed Lockwood’s EcoSmart range to minimise impact on the environment using the latest in eco-innovations. Lockwood has endeavoured to make EcoSmart homes as self-sufficient as possible by including on-site power generation, solar hot water systems and rainwater harvesting. The architectural design reflects the progressive thinking of the eco-features, with high, lofty roofs and sunlit living areas that open from the outside in.

In March 2008, the Gullwing, Lockwood’s first EcoSmart show home, opened its doors in Rotorua, to unprecedented public interest. Within six months, the show home was awarded the “Sustainable Innovation and Design” award at the Bay of Plenty Sustainable Business Awards.

The Lockwood Group employs more than 100 people in New Zealand, with a manufacturing complex located in Rotorua. Besides housing, the factory produces a wide range of engineered solid pine components for New Zealand and export markets.

Today, Lockwood buildings have proven themselves globally in thousands of beloved homes, successful restaurants, community health centres, ski chalets, sports complexes, offices, schools, churches, exhibition pavilions, holiday homes, government buildings and even entire shopping malls.



McINTOSH TIMBER LAMINATES



www.mcintosh.co.nz

McIntosh Timber Laminates is New Zealand's leading structural glulam timber manufacturer.

Plantation-grown New Zealand pine forests have established a vast renewable resource for world leadership in structural timber design.

McIntosh started in 1957 with the production of 50-foot-span elliptical arches and now has a long history of complete design, manufacture and supply of glulam packages to the world; it is totally committed to quality. McIntosh Timber Laminates is a New Zealand pioneer of glulam structures using renewable New Zealand pine. Other species such as Douglas fir, macrocarpa and Lawson's cyprus are also available.

Continuous laminations are produced up to any length using structural finger-joints. Quality control testing ensures consistent strength is achieved. The unique McIntosh finger-joint system allows the use of the longest length of in-grade timber, which means the distance between finger-joints in a lamination can be up to 6 m, with an average distance between finger-joints in each lamination of 2.3 m. This contrasts with an average length that may be as short as 400 mm in laminations by other manufacturers.

McIntosh Timber Laminates uses the newly developed A-Grader machine, which uses sound waves to determine the stiffness of timber. This technology was developed in New Zealand and ensures that McIntosh is able to maintain high-quality standards consistently. Timber

is sorted to specific grades before finger-jointing and laminations are arranged so that the proven strength is provided in areas of greatest stress. This ensures the most effective use of the timber resource.

Only kiln-dried material is used in McIntosh glulam. With a moisture content of 12-16% maximum stability is ensured in finished glulam products. McIntosh has saws that cut to an accuracy of +/- 0.5 mm, allowing engineers and designers to have confidence that the beams they design are manufactured to their exact specifications.

Current McIntosh products include:

- Standard beams that can be accurately cut to length and arrive on site sealed or stained and finished ready for installation in either interior or exterior use.
- Curved beams that allow the designer's creative imagination to be realised. Factory-made members can be formed into any practical shape and any desired size.
- Ply gusset portals for the most cost-effective timber portal. Simple and economical knee joints are formed using nailed plywood gussets.



- Angle knee portals with cross-lapped panels factory glued to achieve the knee joint.
- Curved knee portals with laminations running continuously from base to pinned apex and giving a clean, sweeping appearance.
- Bridges that are straight or curved and suitable for pedestrian or road traffic.
- Arches using glulam to make a low-cost, highly efficient structural form well suited to creating large, unobstructed, clear span enclosures.
- Decking for floors and ceilings that serves as a structural component as well as an attractive exposed surface.
- Connections that are purpose made to address the challenge of efficient joinery for timber glulam members.

McIntosh glulam products have been used in hundreds of different buildings including:

- **Industrial:** factories, warehouses, fertiliser stores, wool scourers, aircraft hangars.
- **Commercial:** administration buildings, office blocks, receptions, lounges, hotels.
- **Leisure:** sports centres, swimming pools, grandstands, community centres, resorts.
- **Churches:** chapels, auditoriums, halls, convention centres.
- **Education:** halls, gymnasiums, classrooms, universities.
- **Domestic:** roofs, floor beams, pole houses.

- **Bridges:** road bridges, foot bridges.
- **Landscape structures:** aviaries, shade houses, pergolas.
- **Specials:** columns, bench tops, curved plates.

Grand Hyatt Hotel, Dubai

The architect's ceiling plan was for a structure that resembled four suspended dhow boat hulls, which were originally designed to be supported by steel frames and trusses.

McIntosh designed 34 m long, 7 m deep "keel" trusses that proved more cost effective than steel. The hull shapes were formed with curved glulam gunwales and ribs. The service area for ducting, wiring and pipes is above the gunwales and planking is fixed to the glulam ribs to create the exposed hull shape.

The McIntosh glulam structure in the completed feature ceiling supports a total area of 34 x 56 m.



VERDA NEW ZEALAND

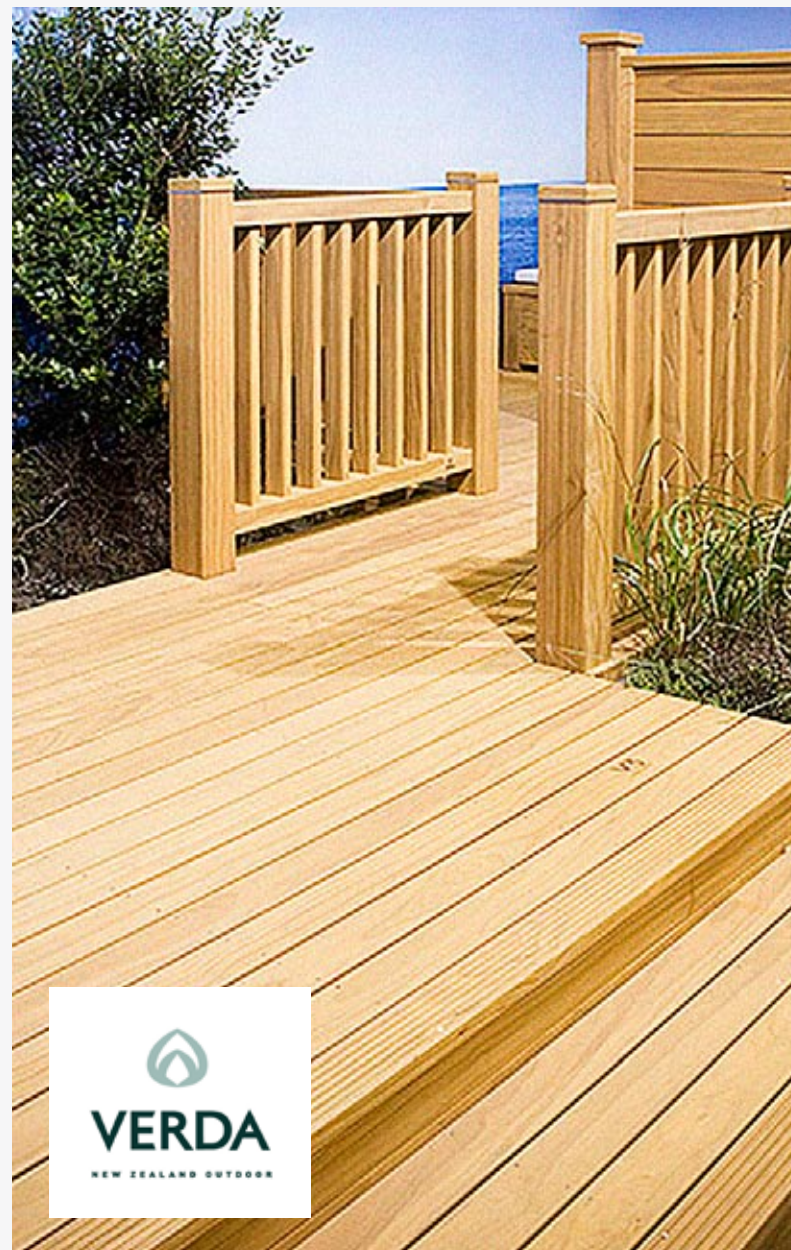
www.verda.co.nz

Verda New Zealand has come a long way in quite a short time, developing from a supplier of commodity lumber to the domestic market into a design-led export company that fills a niche market for high-quality outdoor timber.

Verda now services both domestic and export markets, including Japan, the US, China and Australia and supplies two distinct product ranges under two quality brands. Products in each range share common elements that link them as a family, but each individual product can also stand alone on its own merits.

Integration is an important design element for Verda, from both an aesthetic and a practical perspective. From an aesthetic viewpoint, there are clear advantages for customers in designing a range of outdoor products that work both as a collection and individually. At the practical level, an integrated system provides convenience for architects, landscapers, specifiers and construction crews with simplified installation, time savings, ease of use and flexibility to change as needs evolve.

At the heart of Verda's design culture is finding clever ways to tame wind, temperature variations and the sun's rays so that customers who use its outdoor timber




VERDA
NEW ZEALAND OUTDOOR

products can enjoy as much or as little of the outdoors as they want. The company constantly seeks better and more innovative ways to meet customers' needs and improve operating efficiency, and is at the forefront of technology, logistics and optimisation systems.

Verda New Zealand was established as Key Lumber in 2003, when the founders identified a gap in the market for timber used outdoors for decks, fences, retaining walls and other such landscaping uses. They saw an increasing desire by people to blur the lines between indoor and outdoor living, as a way of improving lifestyles. The business was originally based on buying logs from sawmills, processing them into outdoor wood products, then wholesaling them to timber merchants. Then one of the founders attended the 2007 Better By Design conference and realised that the company had untapped potential.

The company consulted a brand strategist, who suggested a name change to Verda (from the Latin word for "green"). The company was re-named Verda New Zealand Limited in April 2008, to better reflect its aspirations to achieve pre-eminence in sustainable outdoor wood products. The brand strategist's recommendations also led to a separation into two brands:

- V3 - which processes and sells commodity timber.
- Verda - which is focused on exports and timber for outdoor environments.

Verda New Zealand's headquarters is alongside forestry research institute Scion in Rotorua and it has recently launched products that use technology developed by Scion. The patented technology makes clear wood look better for longer, despite exposure to the weather. Verda has built an ongoing research and development (R&D)



relationship with Scion and commits significant ongoing investment into product and process R&D.

The company's long-term focus is on expanding the Verda brand in export markets, especially in Australia, Japan, the US and Europe. Verda believes the technology developed by Scion is appropriate for these markets because the superior product that the technology creates meets demand in these countries for both functionality and good looks.

Verda sources feedstock from a number of large, mid-sized and small sawmills, including its own mill, and several of the supply mills have committed to programmed cuts that provide scale and surety of supply. In addition, Verda is currently investigating partnerships with other New Zealand wood companies to ensure that it has sufficient manufacturing capacity available to meet projected demand. It has also bought a site next to one of its current processing plants so that it has room to expand.

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