

Sustainable timber potential for Northland, New Zealand

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This paper explores the feasibility and potential use of locally grown timber alternatives to chemically treated *Pinus radiata* for domestic construction in the Northland region. Current and potential locally grown alternative timber resources are initially identified through direct contact with local forest managers, sawmill operators, and timber suppliers. This is followed by an investigation and description of the characteristics specific to each of the available timbers. Finally, the paper discusses the implications of using the timbers within domestic construction, and examines what methods are available for architects to use these timbers within the current framework of the *New Zealand Building Code*.

Keywords: Sustainability, timber, Northland.

INTRODUCTION

This paper investigates sustainable timber alternatives to chemically treated radiata, suitable for use in domestic construction within the context of Northland, New Zealand. The Northland focus is due to author's connection to the region, having both lived and worked (in the production forest industry and architectural profession) within the area.

Local supply is regarded as an essential component in identifying sustainable timber alternatives. All timbers considered as sustainable alternatives must be locally grown and milled in the area. Another essential component is that sustainable timber alternatives must display a natural durability, allowing them to be used for construction without the reliance on preservative chemicals.

The paper has focused on architectural issues pertaining to the alternative timbers. The information covered provides a broad understanding of how and where these timbers are used in domestic construction. Detailed research with regard to particular issues like timber strengths and structural grading has already been covered by others, and they provide a valuable resource for those who already have prior understanding of the alternative timber's availabilities and characteristics.

At the core of this paper is local supply, and investigation into the availability of these alternative timbers has been carried out by consulting with local industry. Interviews with nursery managers, forest growers, forest managers, sawmill operators, timber merchants and other related consultants were conducted and recorded to provide a realistic understanding of the scope of alternative timbers. The cited properties and uses of these timbers have been sourced from New Zealand texts to ensure that accurate specifications for locally grown timber are used. To investigate the process of compliance, the current *New Zealand Building Code* standards were referenced, and interviews conducted with building consent officers from each of the four district councils in Northland; Far North, Kaipara, Whangarei and Rodney. An interview with engineers at Scion Research (formerly Forest Research Institute) provided additional information relating to alternative compliance methods.

1. THE RESOURCE – AVAILABILITY

1.1. General Availability

New Zealand enjoys a range of micro-climates which create suitable growing conditions for both exotic and indigenous timber species. Added to this domestic availability, is the opportunity to import many different types of timber from around the world. Examples of common imported alternatives include Western red cedar from Northern America and kwila from Indonesia and around the Pacific (Bullement 2000). Although these timbers can be sourced from plantation forests (in some cases Forest Stewardship Council certified forests), for the purposes of this paper they will not be considered sustainable alternatives because they are not grown in the Northland region.

Like much of the North Island, the Northland area enjoys a temperate climate. With temperatures ranging from between -0.1°C – 30.8°C and privileged to good rainfall (ranging from 1334 - 1490mm/year) and somewhat mild transition seasons (www.clifo.niwa.co.nz), the region's large rural areas provide suitable open space for growing many varieties of timber species. Soil conditions are equally favourable, with a collection of types; from fertile semi-volcanic soils to silt clays located around the main rivers and estuaries and sandy loam soils near the coasts. A drive along the main state highways in the area, S.H-1, S.H-12 & S.H-14, proves that many different tree species grow in the region. Some are not suitable for construction purposes due to poor form, low timber durability ratings or unsuitable timber strengths. However many of these trees have the potential to yield timber that could be used for a variety of purposes in domestic construction.

1.2. Exotic Timbers

According to the MAF 2009 National Exotic Forestry Description, non-radiata exotic forestry equates to about 3% of Northlands exotic forests, much lower than the national statistic of about 10% (MAF 2009: 3). There are 202,286 hectares of surveyed production forestry in Northland, of which 196,229 hectares are in radiata. The remaining 6,057 hectares of mixed alternative timbers comprise mainly exotic hardwoods located in the far north area (MAF 2009: 8). This radiata dominance appears to be due to the proximity of large forestry companies in the area predominantly planting radiata. Some trials of alternative species have been carried out within the Northland area such as the New Zealand Forest Service eucalypt trials in the 1970's (Nicholas acc. 2009), but the trees have largely been milled and the trials discontinued (Newman 2009). This is due in part, to two reasons; the first is radiata can be successfully grown in a range of climates and soil types, a significant advantage over other commercially viable alternatives, which tend to be more site dependant. The other is that radiata timber has an existing well developed market, both nationally and internationally, which has been proven to be a reliable commodity for investment return (Newman 2009).

Although there seem to be very few large woodlots of alternative species in Northland, there are many small wood lots and shelterbelt plantings on farmlands, and some that have been kept to a high level of maintenance. As well as radiata, some of these farm foresters have planted a wide variety of alternatives and in the case of some species, national working groups have been set up to develop silvicultural techniques, and promote particular timber markets; for example eucalypt, cypress, redwood, and Tasmanian blackwood (www.nzffa.org.nz). Despite these alternative woodlots being small in comparison to the radiata forests, specialist sawmills have set up in the region to process these timbers. Examples of these mills include: Midwestern Sawmill in Maungakaramea specialising in *Eucalyptus* species, Cypress Sawmill between Helensville and Silverdale specialising in *Cupressus* species, and the Mahoe Sawmill near Kerikeri that processes anything but radiata. In addition to these sawmills, portable mill contractors operating in the area, are able to mill small volume woodlots that the larger static mills may not.

Based on interviews conducted with local sawmill operators, the predominant alternative exotic timber species currently being milled in Northland appear to be certain *Cupressus* species (mostly *macrocarpa* with some *lusitanica*), and several different variety of eucalypts; the main species being the Eastern blue gum and stringybark groups (*Eucalyptus saligna*, *E. botryoides*, and *E. pilularis* respectively) (Newman 2009). There are limited lots of redwood and Japanese cedar milled which are generally from early shelter belt plantings on farmland (Newman 2009).

Interviews with local forestry nurseries and farm foresters provide a glimpse to what future alternative timbers may be available in the area. Generally the alternative timbers listed above are continuing to be managed, with some notable differences. *Cypress lusitanica* appears to be preferred over the traditional *C. macrocarpa* due to its natural resistance to canker, traditionally a problem with growing *macrocarpa* in humid climates (Newman 2009). Both redwood (*Sequoia sempervirens*) and Japanese cedar (*Cryptomeria japonica*) shelter plantings have declined due to their long rotations and competition, from the popular Leyland's cypress (*X Cupressocyparis leylandii*) with its quicker growth rates (Newman 2009). Of the eucalypts there has been a recent shift away from planting the gum varieties to the stringybark types including the previously mentioned *E. pilularis* (Newman 2009). Another development is the limited plantings of Tasmanian blackwood (*Acacia melanoxylon*) in high density woodlots, although poor tree form has been noted as a significant problem (Newman 2009).

1.3. Indigenous Timbers

Northland is privileged to a variety of indigenous tree species. Many sit on public land in the form of Department of conservation reserves. Other areas exist on privately owned land, some set aside by community groups and/or iwi as managed reserves, and others are protected by individuals placing the forest land under covenant in perpetuity. This ensures areas of natural indigenous forest remain in the area free from exploitation and safeguards them for future generations to enjoy.

Separate to these conservation areas, other indigenous trees on private land (both individual trees and regenerating stands) are also protected under the Forestry Act 1949. This additional protection limits the availability of native timbers in the area, but does not remove the resource completely. The purpose of this act is "to promote the sustainable forest management of indigenous forest land" (N.Z.I.F.U 1993: 6) and is administered by the Ministry of Agriculture & Forestry. Applications can be made to M.A.F to mill indigenous trees on private land, however the volumes allowed from non-plantation trees are limited, and in some cases, the conditions attached to the permits can

seem restrictive to landowners. Additional to the milling permits required, sawmills that process the timber must also be registered with M.A.F to mill native timber.

Despite this added layer of regulation, there has been interest amongst some small foresters for plantation native forests in the Northland area with species like puriri (*Vitex lucens*), kowhai (*Sophora* spp.), kauri (*Agathis australis*), and kahikatea (*Dacrycarpus dacrydioides*) being explored (Newman 2009). However the most predominant native species for plantation forestry seems to be totara (*Podocarpus totara*). Because of the physical characteristics of the timber, and its good growth rates in the area, a special interest group called the Northland totara working group has been formed to promote the timber and research the management of totara in plantation and regenerating environments throughout the North. Additional to these few plantation type woodlots, there are occasional small areas of regenerating native woodlots on private land that are also being milled. The volumes from these lots are however limited and sporadic, with the main species generally milled being totara, with small amounts of kauri and rimu (*Dacrydium cupressinum*) from time to time (Newman 2009).

2. THE RESOURCE – TIMBER CHARACTERISTICS & USES

Noted in Table 1 are the characteristics data for each of the alternative timbers found to be available in Northland. Descriptions of the individual timbers and how they have been previously used in domestic construction have also been included. Generally the pattern of use of these timbers is for appearance products such as linings, flooring, claddings or furniture items, no doubt due to their limited availability, and the premium cost attached.

Where particular timbers are suitable for structural purposes, it seems a shame to bury them behind conventional radiata-type building methods. There is however another option available where such structural elements can be left exposed where they can be architecturally celebrated and enjoyed. An example of this option in use can be seen with Melling & Morse's Music Box house in Wellington. Here the structure of the tall glazed wall has been celebrated by using exposed vertical cypress trusses that are not only "interesting and attractive elements in their own right" (Charleson 1997:10), but also define internal spaces within their bays.



Source: (www.wellington.govt.nz)

Figure 1: Interior of Melling & Morse's Music Box house.

Table 1: Timber Characteristics

Timber Species		Density	Durability Class (Heartwood)	Modulus of Elasticity at 12% M.C (stiffness)	Modulus of Rupture at 12% M.C (strength)	Shrinkage (from green to 12% M.C)	
						Tangential	Radial
Exotic species	Radiata (<i>P. radiata</i>)	500kg/m³	4 Non Durable	9.0 GPa	90 MPa	6.0%	2.6%
	macrocarpa (<i>C. macrocarpa</i>)	485kg/m ³	3 Moderately Durable	7.9 GPa	74 MPa	3.3%	1.6%
	lusitanica (<i>C. lusitanica</i>)	460kg/m ³	3 Moderately Durable	6.5 GPa	70 MPa	2.6%	1.4%
	Leyland cypress (<i>X C. leylandii</i>)	495kg/m ³	3 Moderately Durable	6.9 GPa	85.6 MPa	3.2%	1.4%
	saligna (<i>E. saligna</i>)	660kg/m ³	3 Moderately Durable	11.1 GPa	91 MPa	7.0%	3.8%
	botryoides (<i>E. botryoides</i>)	765kg/m ³	3 Moderately Durable	11.0 GPa	96 MPa	4.7%	2.2%
	pilularis (<i>E. pilularis</i>)	720kg/m ³	2 Durable	13.4 GPa	114 MPa	5.3%	3.0%
	Japanese cedar (<i>C. japonica</i>)	363kg/m ³ – 389kg/m ³	2 Durable	7.2 GPa	66.1 MPa	3.5%	1.3%
	redwood (<i>S. sempervirens</i>)	380kg/m ³	3 Moderately Durable	6.6 GPa	63 MPa	3.2%	1.5%
	blackwood (<i>A. melanoxylon</i>)	680kg/m ³	3 Moderately Durable	14.0 GPa	130 MPa	3.6%	1.8%
Indigenous species	totara (<i>P. totara</i>)	480kg/m ³	1 Very Durable	6.4 GPa	62 MPa	4.0%	2.0%
	rimu (<i>D. cupressinum</i>)	595kg/m ³	3 Moderately Durable	9.6 GPa	88 MPa	4.2%	3.0%
	kauri (<i>A. australis</i>)	560kg/m ³	3 Moderately Durable	9.1 GPa	88 MPa	4.1%	2.3%

Sources: (Bullement 2000), (Clifton 1991),
(Mortimer 2003) & (www.nzwood.co.nz)

2.1. Cypresses (*Cupressus macrocarpa*, *Cupressus lusitanica* and *X Cupressocyparis leylandii*)

As members of the Cypress family, macrocarapa/Monterey cypress (*C. macrocarpa*) lusitanica/Mexican cypress (*C. lusitanica*) and Leyland's cypress (*X C. leylandii*) all share similar characteristics. The heartwood of these timbers are golden brown with a speckled appearance/ or lustre similar to kauri, particularly lusitanica (www.nzwood.co.nz). Of the three, macrocarapa heartwood is the darkest, lusitanica is slightly lighter, and Leyland's cypress has a distinctive pale yellow colour. All timbers have heartwoods with natural durability (Clifton 1991) and paint well, although it has been noted that macrocarapa tends to stain unevenly (Bullement 2000).

As a timber species, macrocarapa and lusitanica have been described as "a most useful all-round farm timber" (Clifton 1990: 131) due to their varied use from house framing and cladding to stock yards and fencing battens. Both timbers have been historically used for framing, exterior joinery, weatherboards, internal panelling and built-in furniture (BRANZ & NZFS 1980-87). Despite the softness of the cypress timbers, they have also been used for decking and T&G flooring (Nicholas acc. 2009). Little has been written about the use of Leyland's cypress timber, perhaps because it has not been used to the same extent as macrocarapa or lusitanica, but with similar properties to the other cypresses, it could be used for similar applications (Nicholas acc. 2009).

2.2. Eucalypts (*Eucalyptus saligna*, *Eucalyptus botryoides* and *Eucalyptus pilularis*)

Of the 250 eucalypt species in New Zealand, the three listed here represent two different groups. *E. saligna* (Sydney blue gum) and *E. botryoides* (Southern mahogany) belong to the Eastern blue gum group, and *E. pilularis* (blackbutt)

belongs to the stringybark group (Mortimer 2003). Both *saligna* and *botryoides* have reddish coloured heartwoods with paler sapwoods, and sometimes, interlocking grains. Although the textures of these timbers are classed as medium, it has been noted that the texture of *botryoides* is slightly finer than *saligna* (Clifton 1991). In contrast to the above Eastern blue gums, *pilularis* has pale yellow heartwood with cream coloured sapwood (Bullement 2000). It too has a medium even texture, but unlike the other eucalypts described here, is straight grained and has a higher durability classification of 2 – Durable (Bullement 2000).

Generally speaking, all three timbers have similar historical uses. The timbers can be used for heavy construction framing, most notably in New South Wales and lower Queensland (Clifton 1991), flooring and decking where the natural durability and timber stiffness characteristics are suitable. Added to this, the attractive colour characteristics of these timbers make them ideal for veneers, finishing work, and built-in furniture.

2.3. Japanese Cedar (*Cryptomeria japonica*)

Japanese cedar heartwood has been described as having “light reddish to purplish-brown colour” (Mortimer 2003: 28), and compared to “Redwood and Western Red Cedar in general character” (Mortimer 2003:28). The timber generally has a straight grain and the texture can be a mix from fine to coarse due to the contrasting growth of the spring and summer wood (Mortimer 2003).

The durability rating of the heartwood allows for some use of the timber in exterior situations, but due to its low strength, its use for structural purposes is limited (Mortimer 2003). Japanese cedar timber is used in internal sarking and panelling, as well as exterior cladding and finishing elements, for example; weatherboards & fascias (Mortimer 2003).

2.4. Redwood (*Sequoia sempervirens*)

Redwood timber ranges in colour from warm reddish brown heartwood to light coloured sapwood (Bullement 2000). It is a soft, low density timber with a straight lustrous grain, even texture and due to its low shrinkage rates, is dimensional stable (Cornell 2002). The timber is easily worked, but requires care when drilling or planing due to its low - moderate density and strength (Patterson 1988).

The natural durability and good dimensional stability makes redwood a suitable timber for exterior joinery and external cladding (Mortimer 2003). In fact, the low shrinkage rates of redwood are well suited for the use of weatherboards as it is less prone to warping, cupping or opening at the joints (Cornell 2002). Additional to this, the easy workability and warm even grain is also a fine attribute for interior panelling and finishing work (Patterson 1988).

2.5. Tasmanian blackwood (*Acacia melanoxylon*)

Blackwood timber has been called a highly decorative wood with a wide range of colours (Clifton 1991). The heartwood is generally a rich brown, sometimes with coloured streaks of reddish brown or black contrasting with the sapwood that is more of straw colour (Bullement 2000). It is easily worked, although nails should be predrilled and the timber should be well seasoned before gluing (Nicholas & Brown acc. 2009). When it comes to coatings, blackwood stains well and is capable of accepting a fine polish finish (Mortimer 2003).

Due to the decorative nature of the timber, blackwood is used more for its appearance than its durability; it has been referred to as a realistic substitute for rimu in this respect (Mortimer 2003). For domestic construction, such uses may include built-in joinery, interior linings or trim and laminated bench tops.

2.6. Totara (*Podocarpus totara*)

Totara timber is fine and even grained with pale reddish - brown heartwood and a lighter pink - brown sapwood (Bullement 2000). The most notable characteristic of the timber is its natural durability; it is one of only two native timbers rated as very durable, the other is silver pine (*Dacrydium colensoi*) (Clifton 1991). The timber is easily worked, splits and cuts smoothly and is dimensionally stable when dry (Clifton 1991). When totara is to be finished with paint, specific primers are needed as the natural extractives in the timber that make it so durable, also cause problems with normal primers drying properly (Clifton 1991).

The historical use of totara timber has been quite varied; from house piles to exterior joinery, built-in furniture to wall framing (Bullement 2000). This remarkable range of uses is largely due to the significant natural durability Totara has, easy workability, and dimensional stability when dry (Clifton 1991). Added to these characteristics, the timber is also attractive with straight even grain making it also suitable for internal finishing work including panelling and sarking.

2.7. Rimu (*Dacrydium cupressinum*)

It has been said that the rimu timber can be “compared with some of the world famous decorative timbers such as walnut teak and mahogany” (BRANZ & NZFS 1980-87: 3/85). The heartwood is reddish brown heartwood with occasional yellowish patches, pigmented streaks throughout and will gradually fade when exposed to light (Clifton 1991). Added to this, rimu has a transitional area between the heartwood and the sapwood that “shows variations in

colour through the lighter tones” (Clifton 1991: 67). The timber has a close and even texture that works and finishes well, is hard wearing, but has been known to be difficult to nail (Clifton 1991).

Similar to totara, rimu has also had a history of varied use in the construction industry. Because of the attractive grain and “pigmented figure” (BRANZ & NZFS 1980-87: 3/85), rimu was not only used for built-in furniture, interior panelling, quality veneer work, (Bulleyment 2000) but with its hard-wearing nature, it also made a good flooring timber. The durability of the heartwood and the favourable machining properties made the timber suitable for weatherboards and framing timber (Clifton 1991).

2.8. Kauri (*Agathis australis*)

Once described as “one of the world’s greatest timbers” (Clifton 1991: 55), kauri heartwood has rich honey brown colour, and a lighter sapwood. The timber has been compared to macrocarpa due to colour similarities and both timbers share a distinctive characteristic speckle or shimmer, but can be distinguished by its much smaller growth bands and lack of cypress odour (www.nzwood.co.nz). The timber is easily worked, stable when dry and accepts a good finish, but it has been noted that the second generation timber is less durable and not as dimensionally stable as the old growth timber (Clifton 1991).

Historically kauri was deemed an all round timber, used for various building elements from concealed framing, weatherboards, flooring and internal appearance products (Reid 1956). However the second generation timber, due to its lack of heartwood, and the sapwoods susceptibility to borer, has limited use potential for building; generally internal finishing and furniture (Clifton 1991).

3. THE IMPLICATIONS – COMPLIANCE

3.1. Methods of Compliance

The structure of the NZBC allows two methods of compliance. The first is a prescriptive method called the Acceptable Solutions, which sets certain rules / details and lists a collection of standards to work within to ensure compliance. The second is termed the Verification Method and allows alternative solutions to be submitted and tested against specified criteria to verify compliance.

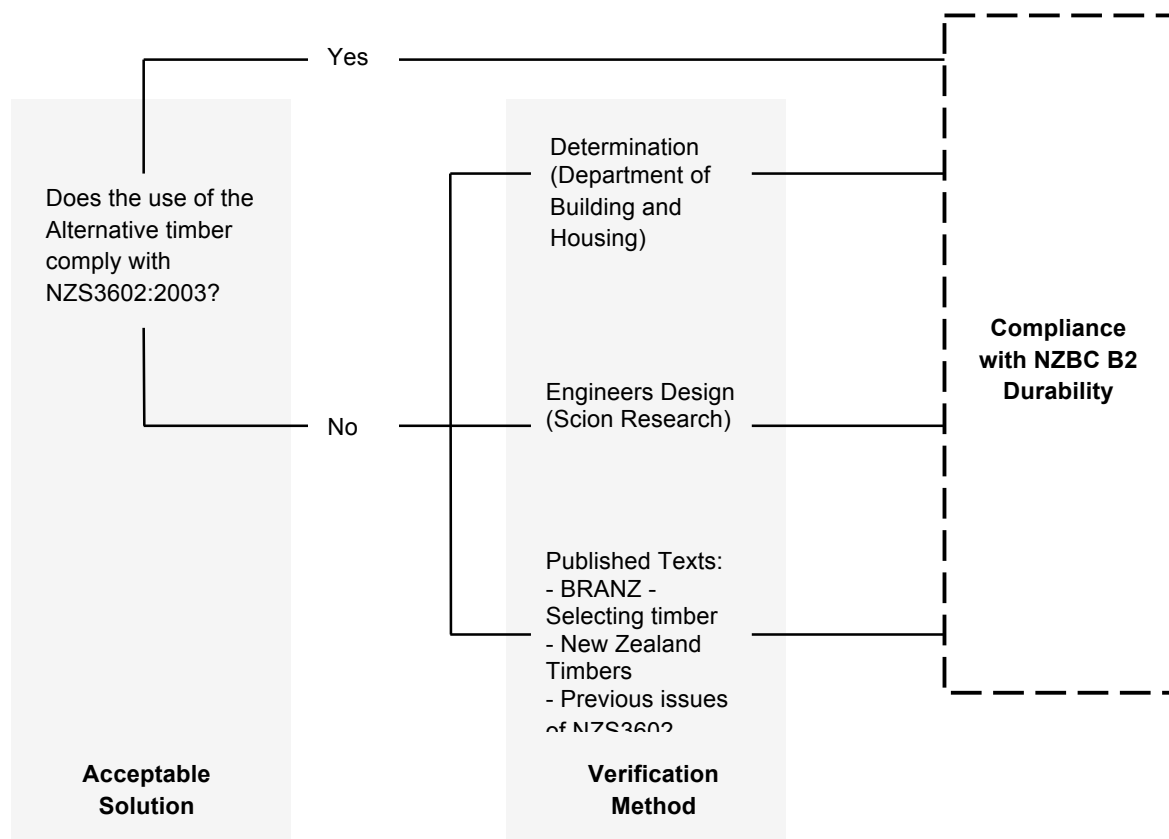


Figure 2: Methods of NZBC compliance

3.2. Acceptable Solutions

The Acceptable Solution specified in the N.Z.B.C Handbook as a means of meeting the durability requirements of timber building elements is NZS 3602:2003. This standard lists various different timbers and specifies their allowed uses as building elements subject to their individual durability characteristics or levels of chemical treatment.

This standard however, appears limited when it comes to alternative timbers to treated radiata; for example, only treated radiata meets the fifty-year structural durability performance requirement for exposed structural members. The same restriction also applies to members in contact with the ground. Another limitation of this standard is the modest number of alternative timbers listed. Of the timbers described in this paper, only the cypresses, the eucalypts, redwood and rimu are listed in NZS 3602: 2003. The permitted uses for some of these timbers also seem restricted when compared to common examples of historic use, and the durability ratings the timbers have been specified in other texts.

3.3. Alternative Solutions

Unlike the one-stop prescriptive format of the acceptable solution, the Verification Method is a two-step process. First, a prior understanding of the alternative timber's characteristics is required to know where each species can be suitably used, and second; you need to understand the process required to prove compliance.

3.3.1. Knowledge from Timber Merchants/Suppliers

In the first instance, this prior understanding can be gained from data sourced from the timber suppliers/merchants. However this data is generally based on imported exotic timbers. The information may be accredited, but the same timbers, when grown in New Zealand, can have different properties that may include lower ratings for durability and/or strength (Clifton 1991: 11). An example of this characteristic can be found with domestically grown saligna, which has been shown to have lower wood density (660kg/m^3) than the Australian grown timber ($\sim 850\text{kg/m}^3$) (Clifton 1991). This overseas information can be used as a preliminary guide, but it is advisable to seek tested New Zealand characteristics for the domestically grown timber. Durability ratings and certain fixing specifications can also be different, and adjustment factors may be required for the size and spacing of certain building elements.

3.3.2. Published Information

There has also been further information published focusing on New Zealand grown timber and some have detailed characteristic data and suggested uses that can be used as a reference at the design stages of a project as well as supporting evidence for a building consent application. Such books include; *BRANZ - Selecting timber*, and N.C Clifton's book, *New Zealand Timbers – The complete guide to exotic and indigenous woods*. Previous issues of NZS 3602 standard have also been suggested as a worthwhile reference in terms of durability for certain building elements from alternative timbers. These previous editions can sometimes include timber species not mentioned in the current revision due to lack of availability and therefore lack of use, particularly some of the indigenous timbers now protected by the Forest Act 1949 (Newman 2009).

3.3.3. Research Institutes

Scion Research (formerly New Zealand Forest Research Institute) is another credible source of information with a 50 year history of New Zealand timber research. Their Engineers can be engaged to provide consultation advice and evidence to support consent applications with regard to issues of durability, strength, fixing resistance and grading requirements and to produce specifications for the design Engineer to work with. Even when selected timbers do not have the required natural durability, the Scion Engineers can sometimes factor allowances of decay, and specify the required element size that will ensure it will be sufficient to meet the 50year structural requirement (Newman 2009). Building officers from each of the four district councils in Northland have all indicated they would generally accept evidence from Scion research for NZBC compliance (Newman 2009).

3.3.4. Determination Information

Another compliance method outside of the acceptable solution is to apply for a determination from the Department of Building and Housing. This is a situation specific decision from the DBH stating, whether or not a building method or material complies with the NZBC. This option has an approximate 60 day turnaround time from when the application is made to the final determination is issued excluding any waiting time required for further information. The cost of the application is \$250.00 plus G.S.T for domestic scale projects (at the time of writing). However, allowance should be made for the preparation of the application which can sometimes require the inclusion of additional information including reports and design calculations.

Despite being site and situation specific, previous D.B.H determinations that are similar in nature, can also be used to help supplement compliance information for a building consent application. These previous determinations are however limited. In terms of alternative timbers used, macrocarpa and Lawson's cypress appear to be the only timbers that have had successful determinations issued for compliance to use as building elements to date. These determinations all refer to exposed structural elements in exterior situations, and are therefore beyond the scope of the current acceptable solution.

CONCLUSION

The availability statistics, noted earlier, clearly show the supply dominance that radiata has over alternative timbers in the Northland region. Whether we like it or not, treated radiata timber is the industry standard, and will almost certainly remain so for some time. Regardless, this paper has demonstrated that sustainable alternative timbers suitable for domestic construction are available in Northland, and currently there are several different processes that allow this resource to be used within the Building Code. Knowledge of these alternatives is paramount to maintaining this limited resource, and encouraging wider use of them. This is a long-term strategy, but if we are able to increase awareness and demand now, we can ensure a stronger and more diverse supply of alternative timbers in the future. For the time being though, these alternatives provide an additional palette to the world of architecture and remain something special. From the auburn glow of a saligna floor, to the spicy aroma from a macrocarpa window frame drenched in sunlight, these alternative timbers enrich our everyday experience of the architecture.

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REFERENCES

- About Determinations* (2010). Retrieved from <http://www.dbh.govt.nz/determinations-about-determinations>
- Bergin, D. (2003). *Totara – Establishment, Growth and Management - New Zealand Indigenous Tree Bulletin No.1*. NZ Forest Research Institute Limited, Rotorua.
- Bullement, A. (2000). *Selecting timber: A guide to choosing timber for use in building*. BRANZ: Porirua.
- Charleson, A. (1997). Case Study. *Timber Design Journal*, Vol. 6 (Issue 3), Pages 10 & 11.
- Clifton, N.C. (1990/1991). *New Zealand Timbers – the complete guide to exotic and indigenous woods – Revised Edition*. GP Publications: Wellington.
- Cornell, W. (2002). *N Z Redwood Growers Handbook*. Diversified Forests Ltd: Henderson.
- Design Aids* (2009). Retrieved from <http://www.timberdesign.org.nz/design.cfm/viewcat/21>
- Mortimer, J. (2003). *A Selection of Alternative Timbers*, Taitau Books: Hamilton.
- National Exotic Forest Description* (2009). Retrieved from <http://www.maf.govt.nz/mafnet/publications/nefd/national-exotic-forest-2009/>
- Newman, N. (2009). Sustainable Alternative Timbers. *Negotiated Study Report (BAS)*. Unitec Auckland.
- Nicholas, I (editor). (acc. 2009). Best practice with Farm Forestry Timber species – No.1: Cypressess. *NZFFA Electronic Handbook series*. Retrieved from <http://www.ensisjv.com/Portals/0/Cypresses>
- Nicholas, I (editor). (acc, 2009) Best practice with Farm Forestry Timber species – No.2: Eucalypts. *NZFFA Electronic Handbook series*. Retrieved from <http://www.scionresearch.com/Portals/0/Eucalypt>
- Nicholas, I. and Brown, I. (acc. 2009). Best practice with Farm Forestry Timber species – No.4: Blackwood. *NZFFA Electronic Handbook series*. Retrieved from <http://www.scionresearch.com/Portals/0/BW>
- NZ Indigenous Forestry Unit. (1993). *A Guide to the Forests Amendment Act 1993 – Outlining the law affecting harvesting, milling and exporting of timber from indigenous forests*. Wellington Indigenous Forests Management Unit, Ministry of Forestry: Wellington.
- Standards Association of New Zealand. (2003). *NZS 3602:2003 New Zealand Standard – Timber and wood based products for use in building*. New Zealand Standards Council: Wellington.
- Other Species* (2009). Retrieved from <http://www.scionresearch.com/general/science-publications/science-publications/technical-reports/forest-management/other-species2>

Patterson, D. (1948/1988). *Commercial Timbers of the World*. Gower Technical Press Ltd: Aldershot.

Reid, J. (1956). *New Zealand Building Timbers*. Government Printer: Wellington.

Scott, S. (1987). *Imported Timbers in New Zealand*, Government Printing Office Publishing: Wellington.

Special Interest Groups (2009). Retrieved from <http://www.nzffa.org.nz/special-interest-groups/>

The National Climate Database (2010). Retrieved from <http://www.clifo.niwa.co.nz>

Timber Species (2009). Retrieved from <http://www.nzwood.co.nz/what-wood/timber-species/>

Wellington Case Studies – Pugh House (2010). Retrieved from <http://www.wellington.govt.nz/services/environment/sustain/case/pugh.html>