



Stop the rot – durable wood

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Every good forestry research institute needs a graveyard. The wooden stakes in Scion's graveyard are not marking the last resting place of ancient foresters. They are part of long running tests to evaluate wood durability.

Examples of wooden stakes, poles, posts, cladding and decking have been buried in the ground, propped up on bearers and exposed to the elements at the Whakarewarewa site since about 1940. The graveyard allows wood and wood products to be field tested where there is a high decay-hazard over a long time.

The Whakarewarewa graveyard is one of four around the country. Each of the sites poses different environmental challenges. Rotorua air is acidic and full of sulphur. The soil at Glenbervie near Whangarei is wet clay. The site near Waiterere Beach close to Levin is wet and sandy while the Hanmer site is dry and stony. The last three are ex-Forestry Service sites now in private hands.

Graveyard testing is the ultimate test of durability, according to Tripti Singh, a scientist who specialises in wood preservation research at Scion. The long-term effectiveness of a new timber treatment, or the performance of natural durable species such as totara, can be gauged after long term contact with soil. Many of the current wood preservatives and New Zealand-grown naturally durable timbers have been tested in Scion's graveyard and are now included in New Zealand standards for the chemical preservation of timber and for timber used in building.

The graph shows example of results obtained from stakes, which are only 20 by 20 mm in size, from different species tested together in the Scion Rotorua graveyard. The durability different index of condition is the average rating for all of the specimens in a group where 10 means the timber is sound and zero means a failure.

What rot

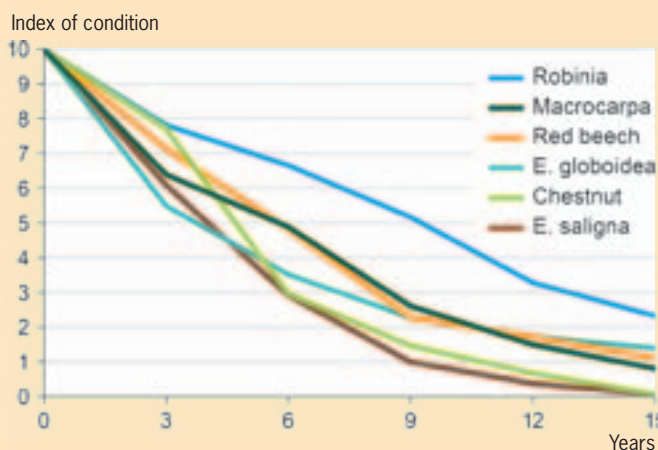
Wood decay is a natural process which allows the nutrients contained in wood to be recycled. While this is desirable in a forest, it is not so good when a fence post fails, or your barbeque guest falls through the deck.

Rot is caused by fungi which secrete enzymes and other chemicals that destroy different components of wood. White rots break down lignin and cellulose resulting in white, moist and spongy looking wood. Brown rots break down cellulose and hemicellulose. This process also produces hydrogen peroxide which diffuses through the wood leading to decay not directly related to the fungus. The decay caused by the hydrogen peroxide causes the wood to shrink and crack into rough cubes. Dry, crumbly-looking brown rot is sometimes wrongly called dry rot, but this is a misnomer – all rot is caused by the presence of moisture.

Insects also pose a threat to wood. New Zealand is fortunately free of termite species which chew their way through houses. Species of native termites are very rarely found outside forests.

Defining durability

Living trees have several lines of defence against fungi – bark, sapwood then the heartwood. Stem decay fungi cannot infect a tree through intact bark. Sapwood cells can respond to an invasion via a 'doomsday' response in which some cells kill themselves in the presence of fungi resulting in conditions which are unfavourable to fungal growth. In conifers, resin can be piped in to seal off an infected area. The xylem can also react to wall-off an invader.



Durability classes average in ground and above-ground life expectancy and some commonly grown New Zealand examples

Natural durability class	1 Very durable	2 Durable	3 Moderately durable	4 Non-durable
In the ground	Over 25 years	15 to 25 years	5 to 15 years	Less than 5 years
Above ground	Over 40 years	15 to 40 years	7 to 15 years	Less than 7 years
New Zealand grown timber examples	Totara, silver pine, <i>Eucalyptus cladocalyx</i>	<i>E. globulus</i> , <i>E. pilularis</i> , red beech, hard beech, mountain beech, oak	Black beech, rimu, matai, kauri, macrocarpa, redwood, <i>E. fastigata</i> , <i>E. dobligua</i>	Poplar, tawa, Corsican pine

Heartwood is different. As a tree grows, chemical compounds, called extractives, are deposited into the cells in the centre of the stem. Many extractives are bioactive, with antimicrobial, antifungal or insect repelling or killing properties. When these cells die and form heartwood the extractives contribute to an environment which is inhospitable to fungi.

When it comes to timber, only the heartwood is durable – sapwood, regardless of tree species, is not durable. Natural durability is rated on timber performance in contact with the ground and above-ground. Durability in New Zealand is measured using the Australasian classification AS 5604-2003, which classifies timber into the four classes shown in the table above.

There can be considerable variability within species, with durability affected by genetics, growing conditions, climate and wood age. In-service conditions vary too, which is where the value of having graveyards with different soil and climatic conditions comes in.

Proving and improving wood durability

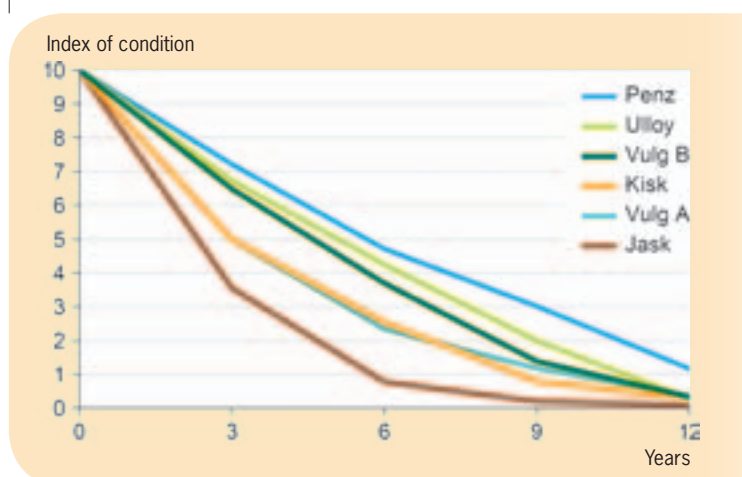
The solid wood processing team at Scion focuses on assessing and improving the durability of timber. Tripti Singh and her team work with industry locally and internationally, testing the durability of wood products and setting and reviewing standards for good building practices. They are also investigating ways to expand opportunities for using wood products by improving durability. This includes developing new preservative systems and new wood processing technologies.

An active area of research is looking at alternative treatments that could replace current preservatives such as chromated copper arsenic, known as CCA, which is used extensively to increase the durability of radiata pine. The chromium binds the copper, which protects against decay and bacteria, and the insecticidal arsenic component, to the wood cellulose and lignin. CCA is very effective, but disposing of CCA-treated wood in New Zealand means

either sending it to controlled landfill sites or incineration in an appropriate facility. In many countries, the use of CCA-treated timber is restricted due to the toxic elements involved, particularly for residential applications. A preservative to replace CCA would benefit the environment and help ensure market access for exports.

Heartwood hints

Extractives from durable heartwood are known to protect the timber from fungal and insect attack. Black locust or *Robinia pseudoacacia* is an excellent example of this. Researchers from Mendel University in the Czech Republic extracted a range of compounds from black locust heartwood. After non-durable European beech was impregnated with the extracts the wood's durability class increased to moderately durable.



The Scion team have looked at heartwood extractives as part of their search for effective new preservatives with low or no toxicity. They have also considered bioactive extractives from other sources, including agricultural and horticultural waste, essential oils, medicinal and native plant extracts, natural biocides and compounds generally recognised as safe, such as food preservatives.

The extensive screening programme has identified a number of potential compounds. The process starts in the laboratory in petri dishes where the inhibition or not of fungal growth in the presence of different materials is observed. More than 20 compounds with anti-fungal properties have been identified.



Screening extracts for bioactivity

Two possibilities

Identifying active compounds is the first step in the process. This is followed by the development of a water-based formulation containing the active compound which subsequently has to impregnate timber and, most importantly, not leach out again.

To date, two compounds have successfully passed through the series of laboratory trials. The most promising is now being evaluated in cladding, decking and exterior joinery in long-term field trials in the Whakarewarewa graveyard and the Oregon State University's graveyard in Hawaii where termites are present. The field trials are being assessed yearly. The team have also come up with a method of quantifying the novel bioactive in treated wood for quality assurance purposes.

The screening work has taken around five years. Identifying new wood preservation candidates is likely to be much faster in the future. Genome sequencing is becoming more and more common as costs decrease and the available computing power which is needed increases. Genomes can be 'mined' or searched for DNA sequences known to code for enzymes associated with particular bioactive compounds.

Investigating technology such as supercritical carbon dioxide extraction to remove water and impregnate wood with potential preservatives is also part of the research programme. Introducing new compounds into wood cells is comparatively easy – the hard part is ensuring they do not leach out when the wood gets wet. Possible solutions to the problem include binding the

preservative directly to cellulose or lignin, or attaching a second chemical or polymer to the preservative that can bind to wood components.

Moving from adding active components to wood, an alternative approach to increase wood durability is to modify the structure of the wood. This can be done simply by heating wood in the absence of oxygen. This causes permanent physical changes that prevent the wood cell walls and interiors from absorbing and holding water. Other chemical-based ways to modify wood structure were outlined in the November 2016 issue of *Tree Grower*.

Naturally durable woods in New Zealand

A number of native and exotic timbers grown in New Zealand are naturally durable. A classic example is totara, which was widely used by early European settlers for piles and fence posts, many of which are just beginning to fail now after more than 100 years of service.

Naturally durable timbers can be an alternative to preservative treated timbers such as radiata pine. An obvious group to explore are the eucalypts, some of which fall into durability class 1 or 2. The New Zealand Dryland Forests Initiative is working to identify and develop ground-durable eucalypt species for dry regions. They have selected the following as their focus for tree improvement work –

- *Eucalyptus argophloia* – western white gum
- *Eucalyptus bosistoana* – coast grey box
- *Eucalyptus globoidea* – white stringybark
- *Eucalyptus tricarpa* – red ironbark
- *Eucalyptus quadrangulata* – white-topped box gum.

These species were chosen for their durability, fast growth, stiffness and strength properties, resistance to drought, frost tolerance and established timber potential based on Australian experience. A number of alternative species are included in New Zealand building standards. They provide niche opportunities not open to radiata.

Along with natural durability comes attractive appearance and good regional or heritage stories, especially with indigenous species. With wider potential applications and options leading to more certain markets, planting other species is likely to be more financially attractive to owners of small to medium forests as well as larger forestry concerns.

The new preservation and other technology that Scion is developing will allow the wood processing industry to move to manufacturing and exporting technologically differentiated and high-value materials. New research on naturally durable timbers will also help develop niche markets for alternative species, making planting and growing them more attractive. None of the work would be possible without graveyards, suggesting we should look at them with new eyes – not dead history but the future of the timber industry. 🌲