Identifying Coast Redwood 'Plus' Trees That Display Superior Heartwood Durability.

PROGRAMME COMPLETION REPORT TO THE SMALL & MEDIUM ENTERPRISE COMMITTEE, FOREST GROWERS LEVY TRUST BOARD (FGR CONTRACT 103).

28th November 2023, Report ITP-TR016

Cover photo: A 'Plus Tree' within Mangatu Cpt. 11, a pruned stand, age 38, that was the source of trees selected for a sawing study. Clonal selections have been made from this stand from plus trees following harvesting.

Project Objective:

To collect increment core samples from 'plus' trees in various Coast redwood (Sequoia sempervirens) stands for the estimation of heartwood durability (using near infra-red spectrometry (NIR)) and basic density. This will identify trees with superior genetic characteristics from which budwood can be collected to be propagated and included in future breeding programmes.

Background:

Coast Redwood Genetics:

The natural distribution of Coast redwood is grouped into three races, northern, central and southern, which differ in the composition of terpenes and terpenoids, compounds found in the trees' resins that have a variety of roles in photosynthesis, growth and disease resistance (*in* Everts, J. & Marjorie Popper, Eds., 2001). The northern redwood forests range from southern Oregon to east of Humboldt Bay in Humboldt County; the central redwood forests extend from southern Humboldt County to northern San Francisco Bay; and southern redwood forests from Alameda to Monterey (Sawyer, John O, *et.al*., 2000). The three zones are further sub-divided into 25 sub-sections, generally based on geographic features (**Figure One**). This zoning varies from the "Tree Seed Zones", 091 to 097, as shown in **Appendix One**.

The Southern redwood forests are comprised of several geographically separate groups and are distinct from central and, especially northern redwood forests compositionally, ecologically and genetically. Redwood trees in this zone often exhibit bluish coloured foliage. Seed from this zone is considered less suitable for New Zealand growing conditions.

Coast redwood is unusual in that it contains six sets of chromosomes (referred to as hexaploidy), which is constant throughout the range and despite differences between the races, taxonomists regard the differences as small enough to classify redwood as a single species.

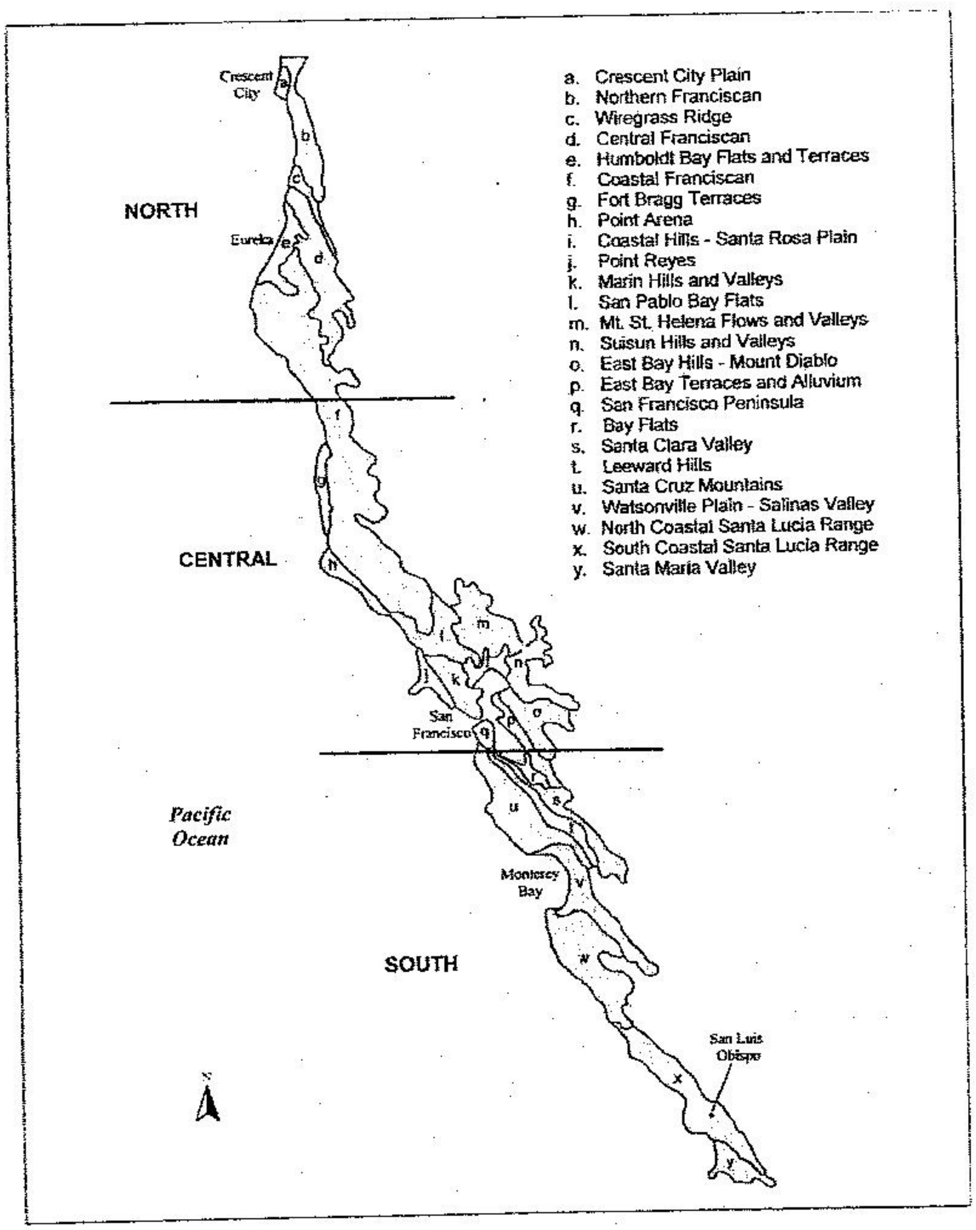
The hexaploidy of Coast redwood probably explains the large variation in various characteristics and indicates the potential for genetic selection of desirable characteristics.

Propagation:

Coast redwood is not well adapted to reproduce from seed. Although cone production can occur at a relatively young age, many stands rarely produce cones, especially in the central zone of the natural range. The factors that induce cone production are not well understood, although there are examples of prolific cone production following flooding events with stands located on river terraces (J Rydelius, *pers.com.*), which suggests that some form of environmental stress is required. Pollen shed is during the rainy season so that cross pollination may be significantly affected during wet seasons. As a result, seed viability is often very low. In the fog belt where natural stands occur, seed germination can be impacted by high moisture levels so that seed may rot in cones, or after it is shed.

In New Zealand, one potentially noticeable difference from California, from personal observation, seems to be that those stands that do produce cones seem to keep producing them annually, although the quantity varies from year to year. Unlike in California, where annual rainfall is low and redwood trees rely on absorbing moisture through their foliage, high soil moisture levels in New Zealand may assist in promoting cone production. In New Zealand, pollen shed is also during late winter, so that pollination can also be compromised by heavy rainfall.

Figure One: Coast Redwood Zones and Sub-Zones (from Reed F Noss, 2000).



Trials to induce cone production have not proven to be particularly successful. Cone production in the Simpson Timber Company seed orchard has required stressing irrigated seed trees by ceasing watering, together with the timely applications of gibberellins (J Rydelius, *pers.com.*).

Most redwood trees recoppice following harvesting. Approximately 90% of trees recoppice and of those about 90% do so in the first year and the rest by year two (W. Libby, *pers.com.*). Most redwood forest owners rely on the re-coppiced crop to produce the next rotation, but with some planting of seedlings (and more recently, clonal tree-stocks) to ensure a full stocking.

The collection of re-coppicing sprouts from the base of the stem of "plus trees" provides the potential for clonal propagation, usually by tissue culture to bulk up numbers rapidly. The initiation of roots from the callus and the transfer of plantlets ex-flask to containers for on-growing are the challenging aspects of propagation by tissue culture and some promising clones can be rejected based on poor propagation success.

Although clonal propagation of select trees of Coast redwood is a logical means of providing rapid genetic gain, obtaining suitable candidates is dependant on the propagation of genetically improved tree-stocks from seed.

Early Redwood Introductions to New Zealand:

The oldest Coast redwood trees in New Zealand date back to the early days of European settlement, with the New Zealand Tree Register recording numerous specimen trees established around the Country during the 1850's – 60's (https://register.notabletrees.org.nz/) and it appears from the details in **Appendix Two**, that some early seed collections would have been made from these stands.

Given the good growth of well-sited specimens, it is perhaps unsurprising that the Forest Service imported several large collections of seed from California in the late 1920's-30's to be grown at various nurseries, with seedlings established in various forests around the Country (refer to **Appendix Two**). Further details are presented in **Table One**.

Table One: Details of Sources of Some Early NZ Forest Service Seed Imports.

Seedlot	Quantity (lbs)	Source
27/33	1098	Harvesting operations, Union & Pacific Lumber Companies, Oregon
28/69	227	Various locations, Mendocino & Humboldt Counties.
29/159	75	Ball Creek, Pacific Lumber Co., from squirrel storage sites.
29/160	72	Ten Mile River, Fort Bragg, harvest areas by Union Lumber Co.
30/165	850	Ball Creek, Pacific Lumber Co., pt. squirrel site, pt. harvest areas.
30/166	230	Ten Mile River, Mendocino Co., harvest areas by Union Lumber Co.

In addition to the NZFS importations, the Annual Reports from 1924 to 1927 of the Pacific Lumber Company of Scotia, Humboldt County, California, record the export of approximately 2,200 lbs of redwood seed to the New Zealand Redwood Timber Company Inc. of Auckland (**Appendix Three**). This company was related to the investment promotions of New Zealand Redwood Forests Ltd. (**Appendix Four**), a company established by Canadian John McArthur in 1925. The company owned 6014 acres of freehold land near Putaruru and by 1929 had established 1025 acres in Coast redwood. In 1934 the government passed the Companies (Special Investigations) Act to investigate McArthur's business practices and in 1935 passed an act to liquidate his companies. (https://natlib.govt.nz/records/33845763). Some of the company's land became part of NZ Perpetual Forests, which issued a prospectus in 1931, later described as "Junk Bonds" and the company came close to collapse in the 1930's depression. However, it survived to eventually provide capital for the formation of NZ Forest Products.

NZ Based Seed Collections:

Appendix Two shows that many of the Coast redwood seed collections from the late 1930's to 1980 were made from Whakarewarewa Forest, predominantly from the 1901 established stand now known as the Redwood Memorial Grove (Cpts. 1 – 2). This stand apparently produced cones quite regularly and was a handy source for seed collection for the adjacent Forest Research nursery.

The collections from this Whaka stand were unfortunate. Seedlings produced from this seed source were used to provide "the New Zealand Land Race" in the Rotoehu Provenance Trial, established in 1981. Unlike most other provenance trials of other species in which a NZ Land Race has generally preformed very well, this seed source performed very poorly and exhibited symptoms of in-breeding (G. Vincent, 2001). It is assumed that the seed used to establish the original Whaka stand was obtained from possibly a single (or few) parent tree(s).

The Interim Growth Model of New Zealand Redwood (Kimberley & Dean, 2005) was largely developed from stem analysis of destructively sampled trees, together with newly established permanent sample plots in most of the same stands. The choice of stands was limited to those of an age where no mortality was evident. Several of these stands were established from seed derived from the Cpt. 1 Whaka Forest stands and exhibited poor growth and form.

The issue of potential in-breeding from NZ-based seed sources was of particular concern to Professor Bill Libby, Emeritus Professor of Forestry, UCLA Berkely. He encouraged New Zealand redwood growers to source seed from NZ stands of known genetic diversity, or from Californian sources.

NZ Forestry Limited (NZF) carried out seed collections from several North Island stands during the period 2006-10. 'Plus trees' were identified and increment cores taken to assess heartwood content and basic density (testing for heartwood durability not being an option at that stage). The seed extracted was classed as either climbing select or bulk and grown at Cambridge Nursery, predominantly for NZF clients. One attribute of New Zealand sourced seed is that it is resistance to 'damping off' and *Botrytis* infection, unlike imported seed, which is highly susceptible.

More Recent Californian Seed Importations:

Bill Libby spent several years in New Zealand working at the Fletcher Challenge Forests facility at Te Teko. It was during this time that he recognised the potential for redwood grown in New Zealand. He was responsible for introducing a selection of trees from the 'Kuser Collection', which were made available to farm foresters in various parts of the Country (Libby, 2002).

The Rotoehu Provenance Trial was established in 1981 from seed obtained by Professor Libby. The trial was not a true provenance trial in that the seed sources used were not a comprehensive collection from throughout the natural range, but essentially, what seed was available at the time from various sources. Some seed sources were from relatively genetically diverse collections, but others were from only a small number of parent trees, typifying the difficulty with seed collection within the natural range. Out-crossing of the various seed populations has the potential to provide a valuable seed source for New Zealand. However, Rotoehu Forest is regarded as a particularly benign site and the trial is yet to show any sign of cone production. Further treatment of the trial is discussed below (under Clonal Sources).

Concerns over potential in-breeding from New Zealand redwood stands encouraged the use of seed imported from California. However, seed is often not readily available from desirable parts of the range. Quantities of seed have been imported from the Santa Cruz area, plus from a stand near Oakland, which produces seed regularly, but is thought to be not a natural stand. Quantities of seed from these sources were commissioned independently by the Soper-Wheeler Company, Wade Cornell and Appleton's Tree Nursery (Appleton's) in 2005.

Appleton's mixed importations of this with seed from local Nelson collections. However, evaluation of the performance of imported Zone 97 seed by Appleton's has led them to decide to no longer use seed from this part of the range. Unfortunately, seed from this source continues to be imported into New Zealand, primarily by Proseed, due to the difficulty of obtaining seed from other sources.

Wade Cornell is a New Zealand based tree enthusiast who has been responsible for a number of seed importations into New Zealand. He has worked closely with Professor Bill Libby and the Californian based New Zealand trained redwood researcher, Pascall Berrill, and in recent years has focused on collections from the arid inland margins of the natural range on the assumption that seed from these sources may have value to New Zealand due to climate change.

Following the decision of the Soper-Wheeler Company of California to purchase land for forest development in New Zealand in the early 2000's (see below), their original New Zealand manager, Jim Rydelius, arranged a number of other seed importations, including seed from the Simpson Timber Company first generation seed orchard, located at Anderson, which may have included some full-sib controlled-cross seed, plus seeds from its seed bank that became surplus to requirements once their clonal planting stock became available. This has largely been deployed in The New Zealand Redwood Company estate.

There is increasing demand for redwood seed in northern California due to increased virulence of Swiss needle cast (*Phaeocryptopus gaeumannii*) on Douglas fir, which is causing northern Californian forest owners to convert mixed Coast redwood – Douglas fir stands to redwood only. This demand is apparently resulting in seed from the southern zone being used to grow seedlings for use in the northern zone. Appleton's have developed a good working relationship with Carl Jachovitch, the primary redwood seed collecting arborist in California and now obtains a preferential supply of seed from the northern & central zones depending on availability.

Clonal Tree-Stocks in New Zealand:

Introductions by the Soper-Wheeler Company:

In 2000, Bill Libby acted as a guide to a group of Californian forest company representatives to investigate the potential of expanding their forestry operations in New Zealand, given the increasing difficult of acquiring land in California and increasing environmental constraints to forest management. The Soper-Wheeler Company was the only company to make the decision to purchase land in New Zealand, somewhat ironically, because they owned little land suitable for Coast redwood which they regarded as the best species for future growth of the company. (Most of their Californian landholdings were in the Sierra's). Other forestry companies that owned significant area of redwood forest seemed to regard the potential development of a redwood resource in New Zealand as a threat to their existing operations.

The decision of the Soper-Wheeler Company of California to purchase land for forest development in New Zealand, significantly increased interest in the potential of New Zealand plantation-grown redwood. In particular, the production of the more valuable clear grades through intensive plantation management, which were primarily produced from 'old crop' forests in the past and the impracticability of pruning natural second and third rotation forests.

The Soper-Wheeler Company was also interested in Douglas fir, which influenced their decision to commence operations in the South Island where they purchased several small Douglas fir forests, in addition to land for the establishment of redwood in the Conway River area. It was only in later years that they decided to concentrate on the establishment of redwood on land in the North Island, especially in the King Country where better growth potential had been recognised.

Jim Rydelius was appointed as the manager of Soper-Wheeler's New Zealand operations, initially operating under the name JPS, later changed to The New Zealand Redwood Company (TNZRC). Rydelius had previously worked with the Simpson Timber Company (STC) and was responsible for that company's selection programme, the development of seed orchards and the use of clonal propagation to deploy selected plus trees, the only Californian company to develop such programmes.

Soper-Wheeler entered into an agreement with STC to purchase clones for importation into New Zealand and to propagate them under licence for their own use, plus to market them to other interested forest growers. For three years from 2002 250,000 plantlets were imported, consisting of 4-5 clones. Additional STC clones were introduced for several years, until clonal selections made from New Zealand sources began to be deployed and the arrangement with STC was terminated.

The STC selection programme focused only on growth and form. Rydelius took the view that characteristics such as various wood properties should be the focus of second-generation selection programmes so that there was no distraction from the primary objective of volume production. The fact that the insatiable US market for redwood lumber did not differentiate lumber grades based on wood quality provided no incentive to select for such characteristics.

Clonal Selections in New Zealand:

The following cases studies are the primary examples known to the author, but there are likely to be other examples that have not been documented.

FIRST RECORD.

The first instance of clonal propagation of Coast redwood in New Zealand was probably carried out by Tom Hartree, the owner of Te Motu Station inland from Puketapu, Hawkes Bay. He took cuttings from sprouts around the base of the best performed tree in a stand established in 1959 that had been felled to be sawn, cultivated the cuttings and planted them in 1984. The small stand created is probably the oldest clonal Coast redwood stand in New Zealand.

TNZRC STUMPAGE PURCHASE, PUTARURU.

Early in their presence in New Zealand, in 2002 Soper-Wheeler purchased a stumpage sale area located in the Putaruru area from Carter Holt Harvey. Harvesting was managed by NZ Forestry Ltd and the logs sawn at Pukepine at Te Puke. All the produce was tallied to provide details of recovered volume by grade. The stand was established from the early importations of seed from the 1920's-30's and comprised trees of outstanding growth and form (**Figure One**). The superior trees in the stand, based on growth and form, were identified, and marked to identify the stumps post-harvest and sprouts were taken for tissue culture initiation (**Figure Two**). Rydelius was not interested in taking wood samples for analysis, but this was done by NZF personnel.

Of the nine plus trees identified, eight produced sprouts and, I understand that six were successfully propagated. At least two of these are important contributors to the current TNZRC propagation programme following field evaluation.

It is unfortunate that the opportunity was not taken to collect mature sprouts from the select trees for the propagation of aged cutting, or grafts, to contribute to a clonal archive.

THE KUSER COLLECTION.

The Kuser collection is named after the Professor of Forestry, Rutgers University, New York, who was an enthusiast of Coast redwood and undertook this project during sabbatical leave. The project was developed by Professor Bill Libby and Jim Rydelius and aimed to collect samples of seedlings, or failing that, cuttings from throughout the natural range. Collected plants were propagated in stool-beds to provide clonal material to be grown on various sites, both within parts of the US and internationally, in order to evaluate the performance of plants from various parts of the natural range in different environments. Two of the STC clones, RB2 & RB54, were included in the trials as 'index' clones.

As previously indicated, Bill Libby brought selected examples to New Zealand when he worked at Te Teko. Early in his tenure with TNZRC, Jim Rydelius imported the entire Kuser Collection into New Zealand. It was propagated at Scion and at least one nursery in the South Island. Several trials of the full set of clones were established at several locations throughout the Country, with numerous small sub-sets provided to farm foresters and other redwood enthusiasts through out the Country.

It is important to emphasise that the clones of the Kuser Collection were not selected on merit of any attributes and as a consequence no credence should be given to them in terms of value for selection for tree improvement.

Some of the Kuser trial sites in New Zealand have been used to study the interaction between clones and the environment (Meason et.al., 2017), which is the purpose of the collection. This study found that the rankings of the different clones were consistent across two representative sites and that medium-to-high genetic control was found for all growth and wood property traits measured, except epicormic shoots. This means that breeding is likely to produce significant gains for these traits.

THE ROTOEHU PROVENANCE TRIAL.

The 1981 trial was established at a relatively high stocking. Plans were made to thin the trial, which JPS offered to fund if some superior trees could be identified and felled to provide potential juvenile sprouts for clonal propagation, as well as mature budwood to be propagated for development of a seed orchard. Trees were assessed for three categories, *viz*: inferior trees to be thinned to waste; superior trees to form a final crop; and superior plus trees to be felled for propagation purposes. Trees from the latter category were also subjected to destructive sampling for the development of the interim growth model for New Zealand redwood.

Vegetative sprouts collected were introduced for tissue culture at both Scion and Lifetech Laboratories, Auckland. Some of the successfully propagated clones ended up in TNZRC propagation programme and others were used to develop stool-beds at the Scion nursery for cuttings propagation.

Propagation of mature budwood collected from the tops of appropriate trees was attempted to produce mature cuttings at the Scion nursery. Those that did not produce roots after two years were then grafted onto rootstocks. The thirty-six successfully propagated plants were kept in large plastic bags at the Scion nursery but were later transported to Proseed at Amberley for a future seed orchard.

Thirty of the Rotoehu clones are growing in the Long Mile area at Scion.

THE AFOCEL COLLECTION.

Bill Libby, whilst he was at Te Teko, imported clones selected and trialled by the French forestry company Afocel. A selection of these clones was established in 1997 on a property near Welcome Bay, Bay of Plenty. Two of the better performing clones from the Kuser collection were also established in the trial as 'index' clones. None of the Afocel clones have displayed outstanding performance and none have exceeded the performance of the index clones.

LAKE OHAKURI PROPERTY.

The owners of this property are acquaintances of the author of this report. They were nurserymen of ornamental plants and had a love of redwood trees. The property was a holiday site that became their retirement property. They planted two redwood stands on the property in 1999 and 2000 from seedlings grown from the same seedlot. An enquiry to Proseed revealed that the imported seed was collected from a site in the vicinity of Mad River, Humboldt County, which is in the vicinity of areas where the Simpson Timber Company made some of their original plus tree selections.

The author introduced Jim Rydelius to the property in 2005 and he was impressed with the performance of the stand and excited about its genetic origin. TNZRC offered to pay for the pruning and thinning of the stand in return for the ability to make future selections from it.

NZ Forestry Ltd managed the pruning and thinning operations and in December 2005 established Permanent Sample Plots at three stocking rates. Six superior trees were selected during thinning to waste operations and the location marked for future clonal selection. Although this selection age was very early, heartwood development was well advanced (**Figure three**) and examination of the stumps several years later indicated which trees displayed durable heartwood and those that did not.

These stands were included in the NIR heartwood durability study (Meason et.al., 2017).

CTPT.11, MANGATU FOREST.

This stand (see cover photo) was established from seed collected from Cpt.20 Whakarewarewa Forest, which is the very impressive stand adjacent to Green Lake. The origin of the seed to establish Cpt.20 is unknown, but it is clearly a different and superior seed source to that of Cpt.1, the Redwood Memorial Grove. The Mangatu Cpt.11 stand represented a rare example of a pruned and thinned stand at close to optimal age for harvest. As a result, it was chosen to provide trees selected across the diameter range to be used in a sawing study (Marshall and Silcock, 2009). Two 'plus' trees were selected for clonal propagation and several years later when the stand was harvested, further clonal selections were made. Unfortunately, no mature budwood was collected for clonal archive purposes.

EARLY SELECTIONS FROM STANDS DEVELOPED FROM NEW ZEALAND 'PLUS TREE' SEED.

A stand of approximately 90 hectares on the Kingheim estate near Tahora, inland Taranaki, was established from climbing select seed collected by NZ Forestry Ltd in 2010. In 2022, twenty superior trees were treated to induce sprouting and increment core samples were taken for durability testing using NIR analysis. As for the Lake Ohakuri samples, heartwood was well developed in the corewood and four of the trees sampled exhibited exceptional low level of predicted mass loss (i.e. high durability). Three of the sample trees were introduced for clonal propagation and field evaluation.

Figure One: The CHH Stumpage Sale Stand, Putaruru, purchased by the NZ Redwood Company.

Wood Properties:

Early views on the potential for redwood as a viable plantation species in New Zealand were largely negative due to comparisons of the wood properties with those of Californian redwood from old growth forests. However, there is now insignificant production in California from old growth forests, with almost all timber production now from 2nd and 3rd growth forests. This finds a ready market in the US, and the wood properties of New Zealand plantation grown redwood are very similar to those from such forests.

Clifton (1994) noted of the wood from New Zealand grown redwood that "it is brash, brittle, and altogether 'punky'. It is rated moderate durability." However, Cown (2008) summarised early studies of the basic density of New Zealand Grown redwood and in a 2012 report he noted that "despite the big differences in crop age, the measured density of NZ redwood is similar to Californian old growth and second growth timber. He reports an average of around 330 kg/m³, "*but with high tree to tree variation……indicating the potential for genetic selection"* (author's emphasis).

Redwood timber is noted for its low shrinkage and dimensional stability (Colbert & McConchie, 1983).

Durability ratings of timber are assessed by graveyard tests, which for New Zealand grown redwood places it in Class 3 (5-15 years in ground contact – AS 5604,2003), whereas in Australia it is Class 2 (5-25 years in ground contact). However, the graveyard tests indicate the high variation of durability and hence the potential for genetic improvement. In general, the extractives that impart durability to the heartwood increase from the pith to bark but the variable weight loss in laboratory tests suggests that it is highly variable between stems and wood age (Cowan 2012). The NIR study (Meason *et.al.,* 2017) indicated that genotype has a strong influence on fungal decay resistance and that this can be detected by NIR.

Figure Two: Sprouts surrounding the stump of a plus tree in the Putaruru stand.

Figure Three: The Stump of C5, Lake Ohakuri.

Field examination of felled stems at the Rotoehu provenance trial showed some stems with decay in the corewood, whereas others had sound cores. Testing of heartwood durability in Suter block tests demonstrates that the outer heartwood is always more durable than the corewood, unless of course the corewood has high durability. Experience from early clonal selection exercises such as those at Lake Ohakuri and the Kingheim estate found some stems with highly durable heartwood in the core. This feature should be a target for clonal selection.

Meason et.al (*op.cit.*) noted that the heartwood of New Zealand grown coast redwood aged greater than 45 years-old is at least as resistant to fungal decay as the heartwood from Californian second-growth forest trees aged between 80 -100 years.

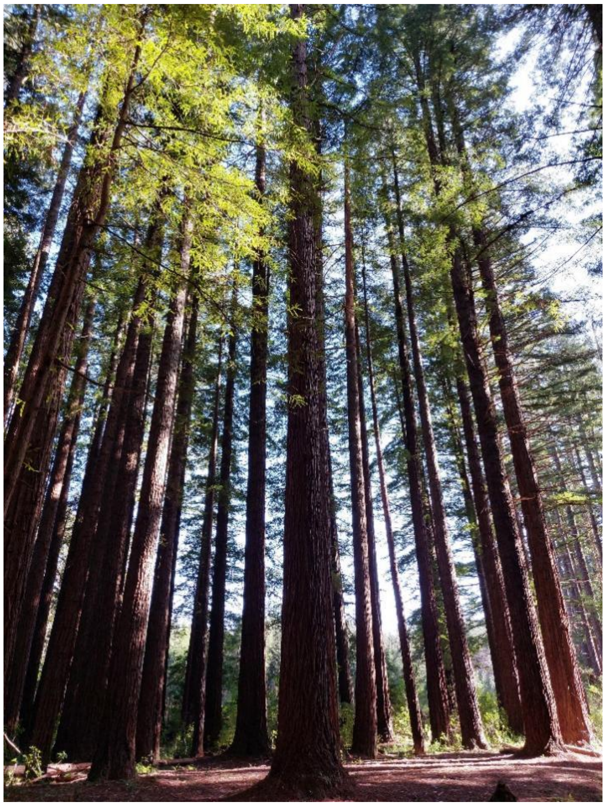


Figure Four: The 'Fish & Game' Stand, Paradise Valley, Rotorua.

Figure Five: Preparing to take an increment core sample, Wright property, Kaharoa.

Figure Six: The Tairua stand.

Figure Seven: Cpt. 51, Mangatu Forest, Whaka Cpt.1 seed, exhibiting inferior genetics.

Forest Sampling:

Stands Selected:

Table Two presents the list of stands sampled by stand age and region. The number of samples represents superior individual trees within each stand, hence only one sample was taken from each. Some of the samples from the Mt. Heslington clonal trial may have been “through & through” cores, i.e. from bark to bark through the centre of the stem.

Table Two: Stands Sampled.

Region	Location	Age	Samples
Canterbury	Homebush	100	5
Coromandel	Tairua	93	9
East Coast	Te Puia 1930	93	10
Bay of Plenty	Paradise Valley, Rotorua	90	12
Bay of Plenty	Kaharoa, Rotorua	86	23
East Coast	Eastwood Hill	73	1
Taranaki	Te Wera	66	3
East Coast	Wharerata 1977	46	11
Wenita	Wenita	37	4
Waikato	Hodgson	34	4
Bay of Plenty	Welcome Bay, Tauranga	26	2
East Coast	Knapdale 1997	26	1
East Coast	Waerenga-o-Kuri 1998	25	7
N Canterbury	Amberley	18	13
Waikato	Waipuna, Huntly	17	9
Nelson	Appleton	16	20
N Canterbury	Conway	15	25
Bay of Plenty	Long Mile, Rotorua	13	35
Nelson	Mt. Heslington	12	36

Several stands targeted for the project were not able to be sampled, due either to access issues following the extreme weather events in the Regions affected (e.g. the Holt Reserve, Hawkes Bay and Manutahi, East Coast), or to not being granted permission by Iwi (e.g. Pukaha National Wildlife Centre and Tararua State Forest Park, Kiriwhakapapa Rd., Wairarapa).

Unfortunately, the Canterbury samples, except for the Amberley clones at Proseed, were sampled using a 10-millimetre increment corer as it was mistakenly assumed to be 12mm. This caused indexing issues for the NIR analysis.

The Amberley samples were the better performed ex-Rotoehu clonal archive trees. Determining the durability and basic density of these trees will assist in making decisions as to whether they should be retained in the breeding population.

Few stands have records of the seed source of the seedlings used to establish them. Most of the pre 1960 stands are recognised as of excellent growth and form and many are likely to have been established from early seed importations to New Zealand from desirable parts of the natural range.

The Welcome Bay stand is comprised of the Afocel clones. Only the two best clones were sampled but were rather disappointing in their performance.

The Long Mile trees are better performed trees from either the Rotoehu provenance trial or from the Kuser collection.

The Conway trees are from TNZRC trial of clones that were part of their propagation programme at the time. Some will provide information on how the durability and basic density of the progeny of clonal selection compare with these features of the parent trees from which they were selected.

The Mt. Heslington trees sampled are the best performed trees of a clonal trial and were included in the programme in order to determine their durability and basic density, which will assist in decisions as to whether they should be retained in propagation programmes.

The Appleton samples are trees established as surrounds to the Mt. Heslington clonal trial, or are clones imported by Appleton's from the UCLA Berkley Russell Reservation field trial area. These are likely to include crosses undertaken by Bill Libby of some of the Simpson clones.

The Waipuna trees include samples from some of the seedlots imported into New Zealand by TNZRC. However, access to these stands was difficult and time constraints limited the extent of sampling able to be carried out here.

Sequoia Action Group NIR Sampling, 2022:

The Sequoia Action Group (SAG) undertook increment core sampling of plus trees in the stands from which seed collections have been carried out in recent years, with the support of Kingheim Ltd. NIR analysis was undertaken at Scion and the results are presented below, as an 'in-kind' contribution to this study.

NIR Analysis Procedure:

The procedure involves the preparation of flat surfaces on the transverse face, and the cores are scanned to measure diffuse reflectance of NIR spectra in the range of 800 – 2700 nm.

The model developed for all-ages by Meason et al. (2017) is used for most data sets used to predict the likely mass loss of a 25 x 25 x 50 mm block exposed to white rot *Trametes versicolor* (L.) Lloyd (strain CTB 863 A) under experimental conditions. Another model also developed by Meason *et.al.* is available for testing of young stands.

Analysis is also carried out to determine the wood density of the cores.

Results:

The Scion report is attached as **Appendix Five A.** The Scion report for the analysis of the SAG sampling of 2022 is attached as **Appendix Five B**.

The following 'key', **Table Three** has been used to identify trees of various categories based on mass loss and basic density.

Table Three: Key to Tables Four to Seven.

		Priority one: Low mass loss & above average basic density.
		Pr. 2: Low mass loss, but <ave. basic density.
		Pr. 3: Ave. mass loss, but >ave. basic density.

Data for the older (pre-2000) stands is presented in **Table Four** and has been sorted in ascending order of percentage mass loss. Twenty-one trees have predicted mass loss values of 2.5% or less and basic densities greater than 320 kg/m^3. The average basic density of these samples is 364 kg/m^3.

A further eight samples have predicted mass loss values 2.5% or less, but basic densities of less than 320 $kg/m^{3.}$

Table Five presents the data for the Sequoia Action Group 2022 samples, all of which are for stands established prior to 2000. It is important to note that the predicted mass loss for these samples is significantly lower than for the 2023 samples. The average mass loss for the 2023 samples is 2.83, compared with 1.85 for the 2022 samples. Only three of the 82 2023 old-aged samples have a mass loss of less than 2.0%, whereas 41 of the 59 2002 samples have a mass loss of less than 2.0%. It seems unlikely that the old-aged stands sampled in 2023 would differ so much from the 2022 stands sampled, which would seem to indicate a difference in the calibration of the spectrometer.

The 2022 sample analysis also presents the percentile of the sample within the distribution of the 'all-ages' model, which seems a lot more convenient manner with which to determine a threshold level to identify the best performers. For the 28 samples with the mass loss at a percentile level of no more than 15%, the average mass loss is 1.64. For the 15 samples with the mass loss at a percentile level of no more than 15% plus a basic density >320 kg/m^3 the average mass loss is 1.59, with an average basic density of 338 kg/m^3.

Table Six presents the summary of data for the South Island stands accidentally sampled with a 10mm increment corer. Due to the calibration issues, the values for predicted mass loss are very low, hence a subjective judgement is required to determine an appropriate threshold for assessing acceptable trees.

Two of the five Homebush samples have very low predicted mass loss and high basic density and three of the four Wenita samples display similar characteristics. The Wenita stand doesn't display particularly impressive form, hence it is unlikely that these trees would be considered for collection of mature budwood to contribute to a clonal archive.

The Conway data is from TNZRC clonal trial, and the identity of the clones is confidential to TNZRC but will assist in decision relating to the choice of clones displaying characteristics of above average durability and basic density. Ten clones display such features, whereas two that exhibit above average durability do not have above average basic density.

Table Seven presents the data from various young (post-2000) stands.

The Amberley trees are the better performed clonal archives selected from the Rotoehu provenance trial. Of 14 sampled, five display low levels of mass loss and high basic density and two exhibiting loss mass loss have below average basic density.

The Mt. Heslington data is from the clonal trial and the data is confidential to the parties that contributed clones to the trial. 19 of the 36 trees sampled display low levels of predicted mass loss, but 8 of these have below average basic density. Note that some trees are repeats of the same clone. Some replicates exhibit acceptable characteristics, whereas others do not, indicating the level of variation that can occur between individuals of the same clone.

The Appleton data from trees in the Mt. Heslington trial surround are disappointing in that few, if any, display acceptable levels of both durability and basic density.

The trees sampled at the Long Mile are unusual in that none display low levels of predicted mass loss. These trees, either selections from the Rotoehu provenance trial, or better performed trees from the Kuser collection, where transplanted from Scion nursery stool-beds and although they have grown well, perhaps their less than usual history is the reason for the very low recorded NIR values and low basic densities. Two Rotoehu clones were sampled both at the Long Mile and at Amberley. Results are quite different, as presented in Table Four.

Table Four: Comparison of wood properties for two clones sampled at Abberley and Long Mile, Scion.

	Clone 774		**Clone 9215**	
	Amberley	Long Mile	Amberley	Long Mile
Mass loss (NIR)	2.57	4.3	2.46	4.9
Basic density	345	283	304	240

Table Five: Mass Loss and Basic Density of Samples from Stands Established Prior to 2000.						
File Name Recieved	**Customer ID**	**Lable**	**Region**	**Predicted mass loss (%)**	**Basic density (kg/m3)**	**Comment**
05_15_23	fg12	Paradise Valley, Rotorua	Bay of Plenty	1.57	368	
Hodgson-Tairua	tr2	Tairua	Coromandel	1.73	401	
28_04_2023	wh9	Wharerata 1977	East Coast	1.96	273	
05_15_23	fg5	Paradise Valley, Rotorua	Bay of Plenty	2.00	345	
Hodgson-Tairua	tr1	Tairua	Coromandel	2.03	338	
28_04_2023	tp69	Te Puia 1930	East Coast	2.08	314	
28_04_2023	tp67	Te Puia 1930	East Coast	2.10	367	
05_15_23	fg4	Paradise Valley, Rotorua	Bay of Plenty	2.11	340	
Hodgson-Tairua	tr3	Tairua	Coromandel	2.12	285	
28_04_2023	wok1	Waerenga-o-Kuri 1998	East Coast	2.16	291	
05_15_23	kw13	Kaharoa, Rotorua	Bay of Plenty	2.19	384	knot
28_04_2023	wh2	Wharerata 1977	East Coast	2.20	445	knots
05_15_23	fg11	Paradise Valley, Rotorua	Bay of Plenty	2.24	353	
28_04_2023	wh4	Wharerata 1977	East Coast	2.24	322	
28_04_2023	ewh1	Eastwood Hill	East Coast	2.28	315	
28_04_2023	tp1	Te Puia 1930	East Coast	2.29	394	
Hodgson-Tairua	tr9	Tairua	Coromandel	2.35	356	
28_04_2023	wh10	Wharerata 1977	East Coast	2.39	399	
28_04_2023	tp70	Te Puia 1930	East Coast	2.39	325	
28_04_2023	kn1	Knapdale 1997	East Coast	2.41	299	
Hodgson-Tairua	tr8	Tairua	Coromandel	2.44	442	
05_15_23	fg2	Paradise Valley, Rotorua	Bay of Plenty	2.44	360	
05_15_23	fg6	Paradise Valley, Rotorua	Bay of Plenty	2.45	292	
TeWera-Waipuna	TW2	Te Wera	Taranaki	2.46	326	
05_15_23	fg3	Paradise Valley, Rotorua	Bay of Plenty	2.48	351	
05_15_23	kw19	Kaharoa, Rotorua	Bay of Plenty	2.49	311	
05_15_23	kw18	Kaharoa, Rotorua	Bay of Plenty	2.53	359	
28_04_2023	tp39	Te Puia 1930	East Coast	2.54	330	
05_15_23	kw5	Kaharoa, Rotorua	Bay of Plenty	2.55	329	
Hodgson-Tairua	tr7	Tairua	Coromandel	2.55	306	
Hodgson-Tairua	tr4	Tairua	Coromandel	2.57	305	
05_15_23	kw1	Kaharoa, Rotorua	Bay of Plenty	2.57	370	near knot
28_04_2023	wh6	Wharerata 1977	East Coast	2.58	308	
05_15_23	kw7	Kaharoa, Rotorua	Bay of Plenty	2.66	330	near knot. the 2 pieces don't match.
05_15_23	kw22?	Kaharoa, Rotorua	Bay of Plenty	2.70	352	missing inner rings
05_15_23	kw23	Kaharoa, Rotorua	Bay of Plenty	2.71	344	
TeWera-Waipuna	TW3	Te Wera	Taranaki	2.72	348	
28_04_2023	wok4	Waerenga-o-Kuri 1998	East Coast	2.75	273	
28_04_2023	wok7	Waerenga-o-Kuri 1998	East Coast	2.79	324	knots
05_15_23	fg9	Paradise Valley, Rotorua	Bay of Plenty	2.80	338	
05_15_23	fg8	Paradise Valley, Rotorua	Bay of Plenty	2.82	374	
28_04_2023	wh5	Wharerata 1977	East Coast	2.83	301	
Hodgson-Tirua	HSN4	Hodgson	Waikato	2.85	336	
28_04_2023	wok5	Waerenga-o-Kuri 1998	East Coast	2.88	298	
Hodgson-Tairua	tr10	Tairua	Coromandel	2.88	315	
28_04_2023	tp68	Te Puia 1930	East Coast	2.90	260	
28_04_2023	wok6	Waerenga-o-Kuri 1998	East Coast	2.91	274	
28_04_2023	wh7	Wharerata 1977	East Coast	2.91	346	knots
05_15_23	kw6	Kaharoa, Rotorua	Bay of Plenty	2.92	338	
05_15_23	af860/20	Welcome Bay, Tauranga	Bay of Plenty	2.94	365	
05_15_23	kw4	Kaharoa, Rotorua	Bay of Plenty	2.95	331	near knot
Hodgson-Tairua	tr6	Tairua	Coromandel	3.00	409	
28_04_2023	wok3	Waerenga-o-Kuri 1998	East Coast	3.01	319	
28_04_2023	tp2	Te Puia 1930	East Coast	3.02	386	
05_15_23	kw11	Kaharoa, Rotorua	Bay of Plenty	3.11	398	
05_15_23	kw8	Kaharoa, Rotorua	Bay of Plenty	3.11	322	
28_04_2023	wh3	Wharerata 1977	East Coast	3.12	336	
05_15_23	kw10	Kaharoa, Rotorua	Bay of Plenty	3.12	352	
Hodgson-Tirua	HSN5	Hodgson	Waikato	3.15	327	
05_15_23	af861/20	Welcome Bay, Tauranga	Bay of Plenty	3.17	351	
Hodgson-Tirua	HSN2	Hodgson	Waikato	3.19	290	
05_15_23	kw14	Kaharoa, Rotorua	Bay of Plenty	3.23	311	
05_15_23	kw12	Kaharoa, Rotorua	Bay of Plenty	3.23	370	
28_04_2023	tp54	Te Puia 1930	East Coast	3.25	313	
05_15_23	kw20?	Kaharoa, Rotorua	Bay of Plenty	3.26	445	
TeWera-Waipuna	TW1	Te Wera	Taranaki	3.29	266	
05_15_23	kw15	Kaharoa, Rotorua	Bay of Plenty	3.35	391	
28_04_2023	wh8	Wharerata 1977	East Coast	3.39	299	
28_04_2023	wok2	Waerenga-o-Kuri 1998	East Coast	3.39	274	
05_15_23	kw17	Kaharoa, Rotorua	Bay of Plenty	3.48	331	
28_04_2023	tp50	Te Puia 1930	East Coast	3.48	317	
05_15_23	kw16	Kaharoa, Rotorua	Bay of Plenty	3.51	328	
05_15_23	kw2	Kaharoa, Rotorua	Bay of Plenty	3.53	315	
05_15_23	kw9	Kaharoa, Rotorua	Bay of Plenty	3.54	361	
Hodgson-Tirua	HSN3	Hodgson	Waikato	3.56	282	
05_15_23	fg7	Paradise Valley, Rotorua	Bay of Plenty	3.57	253	
28_04_2023	wh1*2	Wharerata 1977	East Coast	3.63	321	
05_15_23	kw3	Kaharoa, Rotorua	Bay of Plenty	3.73	294	
05_15_23	kw21	Kaharoa, Rotorua	Bay of Plenty	3.78	314	
28_04_2023	wh1*1	Wharerata 1977	East Coast	3.91	325	
05_15_23	fg1	Paradise Valley, Rotorua	Bay of Plenty	4.30	247	
28_04_2023	tp66	Te Puia 1930	East Coast	4.40	299	
05_15_23	913 ??	Paradise Valley, Rotorua	Bay of Plenty		384	Misplaced???

Table Six: Mass Loss and Basic Density of Samples from Stands Sampled by SAG in 2022.				
Sample ID	Description / Location	Predicted mass loss (%)	Percentile of predicted mass loss	Pith-to-bark Basic density (kg/m3)
CM013	Kuser Trial Tree, Carmichael, Waitoki	2.18	35	319
CM043		1.99	25	323
Rg01	Rongoiti Gardens, Taihape vicinity	1.99	25	321
Rg02		2.35	40	280
Rg03		1.61	5	312
Rg04		1.59	5	319
Rg05		2.23	35	285
Rg06		1.96	25	279
Rg07		2.14	30	307
Rg08		1.67	10	300
Rg09		1.68	10	327
Rg10		2.11	25	286
Rg11		1.90	15	365
Rg12		2.20	35	311
TR01	Taihape Reserve	2.01	25	308
TR02		1.45	2.5	354
TR03		1.95	20	307
TR04		1.89	15	301
TR05		1.72	10	317
TR06		1.49	2.5	323
TR07		1.52	2.5	355
TR08		1.48	2.5	327
TR09		1.45	2.5	319
TR10		1.48	2.5	354
TR11		1.56	5	290
SL1	Skyline, Rotorua	1.67	10	342
SL2		1.93	20	286
SL3		2.19	35	297
SL4		1.94	20	274
SL5		1.76	10	302
SL6		1.79	15	284
SL7		1.91	20	340
SL8		1.40	2.5	323
SL9		1.71	10	349
SL10		2.29	40	332
SL11		2.75	75	351
SL12		2.24	40	288
SL13		1.79	15	286
SL14		2.12	30	277
SL15		2.08	30	279
TK1	Redwood Park, Te Kuiti.	2.27	40	273
TK2		1.69	10	327
TK3		1.46	2.5	333
TK4		1.66	10	367
TK5		1.52	2.5	337
TK6		1.80	15	277
TK7		2.02	25	321
TK8		1.74	10	320
TK09		1.37	2.5	303
TK10		1.88	15	326
TK11		1.65	10	300
TK12		2.12	30	347
TK13		1.77	10	300
TK14		1.90	20	316
TK15		2.00	25	342
TK16		1.85	15	316
TK19		1.86	15	308
TKS5		1.95	20	324
TKS8		1.56	5	283

Table Seven: Mass Loss and Basic Density of 10mm Samples from South Island Stands.					
Lable	**Region**	**Customer ID**	**Predicted mass loss (%)**	**Basic density (kg/m3)**	**Comment**
Homebush	Canterbury	1766	1.0	335	Very mouldy
Homebush	Canterbury	1767	1.2	333	
Homebush	Canterbury	1765	1.4	232	
Homebush	Canterbury	1768	1.7	259	
Homebush	Canterbury	1779	1.7	278	
Wenita	Wenita	17	1.1	343	Very mouldy
Wenita	Wenita	15	1.2	328	
Wenita	Wenita	13	1.2	336	
Wenita	Wenita	9	1.5	307	
Conway	N Canterbury	7	1.3	366	Mouldy
Conway	N Canterbury	9	1.4	293	
Conway	N Canterbury	48	1.4	332	
Conway	N Canterbury	19	1.5	348	
Conway	N Canterbury	6	1.5	316	
Conway	N Canterbury	37	1.5	375	near knot
Conway	N Canterbury	10	1.5	387	
Conway	N Canterbury	30	1.6	367	
Conway	N Canterbury	4	1.6	347	
Conway	N Canterbury	33	1.6	340	
Conway	N Canterbury	2	1.7	338	
Conway	N Canterbury	22	1.7	323	
Conway	N Canterbury	35	1.7	281	
Conway	N Canterbury	3	1.8	389	
Conway	N Canterbury	17	1.8	403	
Conway	N Canterbury	34	1.8	280	
Conway	N Canterbury	31	1.8	324	
Conway	N Canterbury	29	1.8	365	
Conway	N Canterbury	49	1.9	383	
Conway	N Canterbury	1003	1.9	280	
Conway	N Canterbury	1001	1.9	310	near knot?
Conway	N Canterbury	36	1.9	354	
Conway	N Canterbury	60	2.0	308	
Conway	N Canterbury	5	2.0	304	
Conway	N Canterbury	58	2.1	279	

Table Eight: Mass Loss and Basic Density of Samples from 'Young' Stands - Established After 2000.

Stand	Region	Customer ID	Predicted mass loss (%)	Basic density (kg/m3)	Comment
Appleton	Nelson	1_3	2.0	307	
Appleton	Nelson	h28_1	2.3	264	Missing sapwood
Appleton	Nelson	ap2	2.5	261	
Appleton	Nelson	9_1	2.6	321	
Appleton	Nelson	ap1	2.6	265	
Appleton	Nelson	7_2	2.7	311	
Appleton	Nelson	9_2	2.9	317	
Appleton	Nelson	17_2	2.9	264	
Appleton	Nelson	15_2	3.0	323	
Appleton	Nelson	b7_12	3.0	287	
Appleton	Nelson	h17_1	3.0	281	
Appleton	Nelson	10_2	3.0	280	
Appleton	Nelson	h26_2	3.1	343	
Appleton	Nelson	h22_1	3.1	285	knot
Appleton	Nelson	h32	3.2	298	
Appleton	Nelson	10_1	3.2	289	
Appleton	Nelson	ap4	3.3	274	
Appleton	Nelson	44_1	3.4	281	
Appleton	Nelson	15_1	3.5	330	
Appleton	Nelson	26_1	3.6	321	
Mt. Heslington	Nelson	14	0.8	327	
Mt. Heslington	Nelson	14	1.0	346	
Mt. Heslington	Nelson	94	1.9	291	
Mt. Heslington	Nelson	40	1.9	299	
Mt. Heslington	Nelson	125	2.0	310	
Mt. Heslington	Nelson	96	2.1	342	
Mt. Heslington	Nelson	93	2.1	283	
Mt. Heslington	Nelson	3	2.1	315	
Mt. Heslington	Nelson	16	2.1	334	
Mt. Heslington	Nelson	3	2.2	325	
Mt. Heslington	Nelson	53	2.2	296	
Mt. Heslington	Nelson	73	2.3	283	
Mt. Heslington	Nelson	96	2.4	327	
Mt. Heslington	Nelson	98	2.4	341	
Mt. Heslington	Nelson	56	2.4	270	
Mt. Heslington	Nelson	36	2.5	289	
Mt. Heslington	Nelson	46	2.5	306	
Mt. Heslington	Nelson	92	2.5	298	
Mt. Heslington	Nelson	36	2.5	319	
Mt. Heslington	Nelson	121	2.6	337	
Mt. Heslington	Nelson	125	2.6	312	
Mt. Heslington	Nelson	46	2.7	283	
Mt. Heslington	Nelson	93	2.8	267	
Mt. Heslington	Nelson	h32	2.8	288	
Mt. Heslington	Nelson	ap3	2.9	284	
Mt. Heslington	Nelson	98	3.0	320	
Mt. Heslington	Nelson	94	3.0	265	
Mt. Heslington	Nelson	121	3.0	305	
Mt. Heslington	Nelson	4	3.0	285	
Mt. Heslington	Nelson	56	3.1	284	
Mt. Heslington	Nelson	b12	3.1	240	
Mt. Heslington	Nelson	3	3.1	366	
Mt. Heslington	Nelson	73	3.3	291	
Mt. Heslington	Nelson	92	3.6	297	
Mt. Heslington	Nelson	53	3.6	287	
Mt. Heslington	Nelson	40	3.7	294	
Amberley	N Canterbury	776	1.8	360	
Amberley	N Canterbury	9211	1.8	341	
Amberley	N Canterbury	926	2.0	373	
Amberley	N Canterbury	777	2.2	367	
Amberley	N Canterbury	9212	2.3	356	
Amberley	N Canterbury	921	2.4	306	
Amberley	N Canterbury	9215	2.5	304	
Amberley	N Canterbury	711	2.6	322	
Amberley	N Canterbury	774	2.6	345	
Amberley	N Canterbury	757	2.6	345	
Amberley	N Canterbury	927	2.8	295	
Amberley	N Canterbury	772	2.9	309	
Amberley	N Canterbury	9213	3.0	318	
Amberley	N Canterbury	776		352	

Stand	Region	ustomer I	Predicte d mass loss (%)	Basic density (kg/m3)	Comment
Long Mile, Rotorua	Bay of Plenty	M02_1	2.7	303	
Long Mile, Rotorua	Bay of Plenty	D02_3	2.9	254	
Long Mile, Rotorua	Bay of Plenty	D02_3	3.0	252	
Long Mile, Rotorua	Bay of Plenty	D01_5	3.1	306	
Long Mile, Rotorua	Bay of Plenty	H02_1 (H2	3.1	299	
Long Mile, Rotorua	Bay of Plenty	D08_1	3.1	285	
Long Mile, Rotorua	Bay of Plenty	H13_1	3.1	330	
Long Mile, Rotorua	Bay of Plenty	M05_1	3.2	283	
Long Mile, Rotorua	Bay of Plenty	H11_6	3.3	294	
Long Mile, Rotorua	Bay of Plenty	928	3.4	237	
Long Mile, Rotorua	Bay of Plenty	R02_2	3.5	293	
Long Mile, Rotorua	Bay of Plenty	H10_4	3.5	322	
Long Mile, Rotorua	Bay of Plenty	925	3.5	255	
Long Mile, Rotorua	Bay of Plenty	H04_2	3.5	301	
Long Mile, Rotorua	Bay of Plenty	411 / 911?	3.7	248	
Long Mile, Rotorua	Bay of Plenty	H19_1	3.9	334	
Long Mile, Rotorua	Bay of Plenty	H15_1	3.9	284	
Long Mile, Rotorua	Bay of Plenty	H5_4	3.9	279	
Long Mile, Rotorua	Bay of Plenty	H09_5	4.0	318	
Long Mile, Rotorua	Bay of Plenty	182	4.1	278	
Long Mile, Rotorua	Bay of Plenty	1_01_4?	4.1	276	
Long Mile, Rotorua	Bay of Plenty	914	4.1	246	
Long Mile, Rotorua	Bay of Plenty	R02_04	4.2	331	
Long Mile, Rotorua	Bay of Plenty	771	4.3	261	
Long Mile, Rotorua	Bay of Plenty	774	4.3	283	
Long Mile, Rotorua	Bay of Plenty	M05_2	4.3	248	
Long Mile, Rotorua	Bay of Plenty	755	4.4	254	
Long Mile, Rotorua	Bay of Plenty	7510	4.5	269	
Long Mile, Rotorua	Bay of Plenty	H14_3	4.6	306	
Long Mile, Rotorua	Bay of Plenty	756	4.6	280	
Long Mile, Rotorua	Bay of Plenty	763	4.9	290	
Long Mile, Rotorua	Bay of Plenty	9215	4.9	240	
Long Mile, Rotorua	Bay of Plenty	704	5.1	257	
Long Mile, Rotorua	Bay of Plenty	923?	5.4	259	

Discussion.

Table Nine shows the number of trees at each location of all older stands that should be targeted for collection of mature budwood to contribute to a clonal archive and seed orchard.

There is no particular need to consider any of the younger stands sampled in order to obtain archive material at this stage, although some of the clonal material should in the future have mature budwood collected to contribute to the clonal archive for future breeding purposes.

Existing clonal archive material at Proseed, Amberley, derived from the Rotoehu provenance trial, that does not exhibit desirable levels of heartwood durability and basic density should be considered for deletion from future breeding programmes.

Table Nine: Location and number of trees to be targeted for the collection of mature budwood.

Location	Number
Tairua Forest	4
Paradise Valley, Rotorua	6
Kaharoa, near Rotorua	3
Skyline, Rotorua	3
Te Puia, East Coast	4
Wharerata Forest, East Coast	3
Te Wera Forest, Taranaki	1
Redwood Park, Te Kuiti	6
Taihape Reserve	5
Rongoiti Gardens, near Taihape	1
Holmbush, Canterbury	2
Total	**38**

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Chair, Sequoia Action Group, NZFFA.

24th November 2023.

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Appendix One: Seed Zone Map of Northern California.

Del Norte County ——»

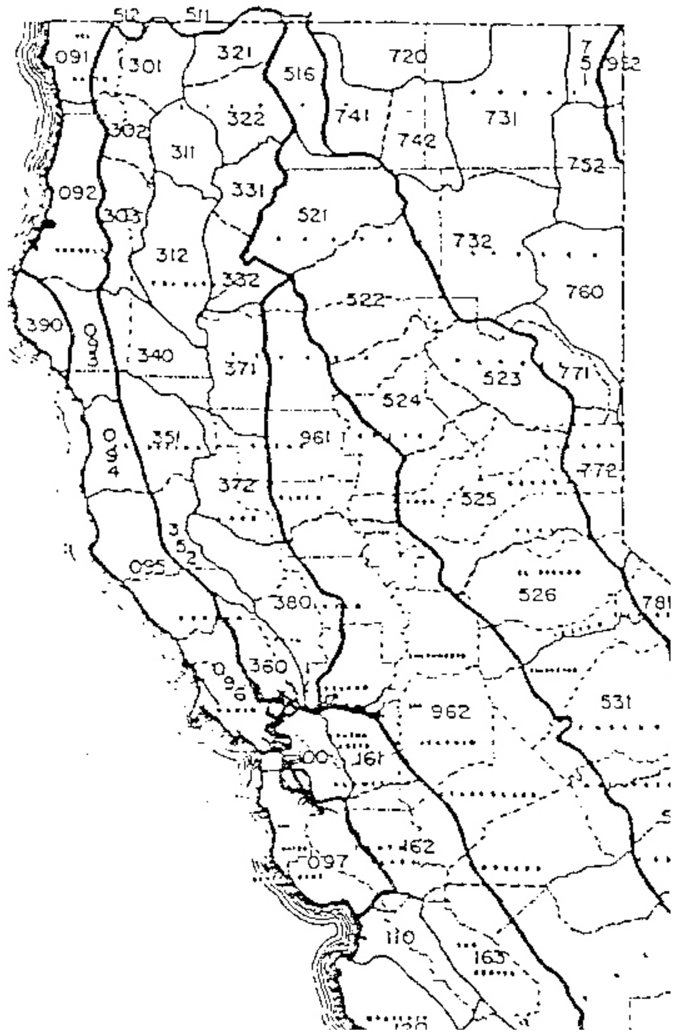
Humboldt County ——»

Mendocino County——»

Sonoma County——»

Marin County——»

SAN FRANSCISCO——»
San Manteo County——»
Santa Cruz County——»
Monterey County——»



Appendix Two: Redwood Seed Collection Records to 1980 (FRI Bulletin 144).

Sequoia sempervirens
coast redwood
Western North America

AK		29	231	SEE HO 28/96
AK		30	222	SEE HO 27/33
AK		30	231	SEE HO 28/69
AK		30	262	SEE HO 29/159
AK		30	263	SEE HO 29/160
AK		31	268	SEE HO 30/165
AK		31	271	SEE HO 30/166
R		27	80	ROTORUA, WHAKAREWAREWA NURSERY
R		28	88	RAWENE
R		33	225	UNKNOWN
R		36	273	ROTORUA,WHAKAREWAREWA NURSERY
R		37	294	NELSON
R		38	308	UNKNOWN
R		39	318	WHAKAREWAREWA NURSERY
R		40	331	WHAKAREWAREWA NURSERY
R		46	387	WHAKAREWAREWA NURSERY
R		54	526	WHAKAREWAREWA, CPT 1
R		58	622	WHAKAREWAREWA, CPT 20C
R		62	687	WHAKAREWAREWA, CPT 20
R		63	709	WHAKAREWAREWA, CPT 1
R		64	736	WHAKAREWAREWA, CPT 2B
R		69	841	WHAKAREWAREWA, CPTS 1& 6
R		71	904	WHAKAREWAREWA, CPT 1
R		72	933	WHAKAREWAREWA, CPT 1
RO	O	75	10	WHAKAREWAREWA
RO	C	76	18	WHAKAREWAREWA
RO	C	77	93	WHAKAREWAREWA
RO	C	78	55	WHAKAREWAREWA
RO	C	79	47	WHAKAREWAREWA
2	0	80	7	WHAKAREWAREWA, LONGMILE
2	0	86	85	ROTORUA, FRI & LONGMILE RD
2	0	87	75	ROTORUA, FRI, LONGMILE AREA
WN		39	30	MASTERTON
WN		46	50	TIKOKINO
WN		48	196	CALIFORNIA, U.S.A.
WN		55	210	TAUMARUITI
WN		56	245	CHELTENHAM
WN		56	263	TAUMARUITI
WN		57	277	TAUMARUITI
WN		58	323	TAUMARUITI
WN		60	371	TAUMARUNUI
WN		61	384	TAUMARUNUI
WN		62	394	TAUMARUNUI
WN		63	421	TAUMARUNUI
WN		66	512	WANGANUI, KOWHAI PARK
WN		67	540	WANGANUI, ANZAC PARK
WN		68	549	WANGANUI, KOWHAI PARK
NM		25	2	NELSON (STOKE) & BLENHEIM
NM		26	7	NELSON AREA
NM		27	12	STOKE, RICHMOND & WAKAPUAKA
NM		28	33	NELSON (STOKE), CAWTHRON INSTITUTE
NM		28	46	SEE HO 27/33
NM		29	65	NELSON, MOUTERE, AND BLENHEIM
NM		30	113	NELSON / BLEHEIM DISTRICTS
NM		31	143	SEE HO 30/166
NM		36	256	NELSON
NM		59	668	NELSON, NILE ST
5	0	83	16	BLUE SPUR
C		29	69	ROTORUA
CY		74	712	HANMER
CY	C	75	36	HANMER
CY	C	76	24	HANMER HOSPITAL
CY	C	79	41	HANMER HOSPITAL GROUNDS
S		60	684	TAPANUI HQ
SD	C	78	98	DUNEDIN CITY COUNCIL GARDENS
7	0	80	56	PALMERSTON
HO		27	33	OREGON, U.S.A.
HO		28	69	MENDOCINO, HUMBOLDT COUNTY,CA.

***Sequoia sempervirens* (cont.)**

HO		29	159	HUMBOLDT COUNTY, CALIFORNIA
HO		29	160	FORT BRAGG AREA, CALIFORNIA
HO		30	165	HUMBOLDT COUNTY, CALIFORNIA
HO		30	166	MENDOCINO COUNTY, CALIFORNIA

Sequoiadendron giganteum
sierra redwood
Western North America

WN		56	244	CHELTENHAM
WN		58	330	WAIPAWA HILLS
C		58	321	CHEVIOT PLANTATION
C		58	337	RAINCLIFF
C		59	354	CHEVIOT DOMAIN
C		59	365	BALMORAL HOMESTEAD
C		61	417	RAINCLIFF
C		61	418	CHEVIOT DOMAIN
C		62	431	RAINCLIFF
C		63	460	RAINCLIFF
C		64	486	CHEVIOT HILLS
C		64	492	RAINCLIFF
C		65	B13	RAINCLIFF
C		67	558	RAINCLIFF
C		72	662	RAINCLIFF
C		73	687	RAINCLIFF
C		73	B13	RAINCLIFF
CY		74	714	RAINCLIFF
CY	C	75	32	RAINCLIFF
CY	C	77	12	RAINCLIFF SCOUT CAMP
CY	C	78	42	RAINCLIFF SCOUT CAMP
CY	C	79	23	ORARI DOMAIN
CY	C	79	24	GERALDINE DOMAIN
6	0	81	14	RAINCLIFF
6	0	82	23	RAINCLIFF
6	0	83	15	RAINCLIFF
6	0	85	32	RAINCLIFF
6	2	85	33	RAINCLIFF
S		59	657	PAPAKAIO
S		61	719	WANAKA STATION
S		63	758	NOKOMAI SIDING
S		63	773	ST BATHANS
S		64	795	NOKOMAI
S		64	803	ST BATHANS
S		65	859	NOKOMAI
S		65	860	ST BATHANS
S		66	906	NOKOMAI
S		67	937	NOKOMAI
S		68	1003	NOKOMAI SIDING
S		69	1022	NOKOMAI SIDING
S		70	1059	NOKOMAI
S		71	1101	NOKOMAI SIDING
S		74	1207	DUNEDIN BOTANICAL GARDENS
SD	C	77	22	DUNEDIN BOTANICAL GARDENS
SD	C	77	31	NOKOMAI SIDING
SD	C	78	58	DUNEDIN BOTANICAL GARDENS
SD	C	78	97	DUNEDIN CITY COUNCIL GARDENS
SD	O	79	49	NOKOMAI STATION
7	0	80	41	DUNEDIN, CHINGFORD PARK
7	0	80	42	DUNEDIN CITY COUNCIL GARDENS
7	0	80	87	TUATAPERE
7	0	83	43	QUEENSTOWN GARDENS+LAKE ESP
7	0	85	38	DUNEDIN CITY COUNCIL GARDENS
7	0	86	20	QUEENSTOWN GARDENS
HO		27	49	CALIFORNIA, U.S.A.

Sophora japonica
Japanese pagoda tree
Japan

3	0	83	40	HASTINGS, FRIMLEY PARK

Appendix Three: Copy of Part of the Annual Report of the Pacific Lumber Company, 1925. (courtesy of J. Rydelius).

The Pacific Lumber Company

ing, some in North Carolina. There have been transplanted in the nursery 100,000 trees for filling similar orders.

Over 300 pounds of seed were collected during the year for the nursery and to fill the standing order of 125 pounds for the New Zealand Redwood Timber Co. Inc., Auckland, N. Z. That company has placed an order for 1,000 pounds in 1927. The amount received for seeds sold covered the cost of their collection, as well as the cost of seeds used in the nursery.

The continued loyal and efficient services of officers and employes are gratefully acknowledged.

John H. Emmert,
President.

Appendix Four: Advertisement for the New Zealand Redwood Forests Ltd Prospectus. (Source: The Auckland Weekly News, 1925).

The Most Profitable Afforestation Investment Ever Offered.

A Few Forestry Facts.

MANY people now realise what wonderful results can be obtained by planting quick-growing trees in certain parts of this country, and more especially in the North Island. A veritable une awaits those who invest in a forestry undertaking re capable management and sound administration are ired.

In spite of the increasing use of substitutes for wood. World's requirements for timber are constantly in- sing instead of diminishing and the problem of the is to make the available supplies keep pace with the -growing demand. Testimony from Forestry Experts Scientists of all countries proves beyond question that world-supply of Timber, both Softwood and Hard- d, is decreasing far more rapidly than it is growing. ceforth every country must rely on its own resources timber supplies. The only hope for the future is to t extensively so as to replace the rapidly disappearing genous forests. Dealing with this question editorially. "New Zealand Herald," February 7th 1924, says:—

"Tree planting, by both the State and the individual, scientific utilisation of our forests, but all forest pro- ts are not simply the urgings of unpractical theorists. y are a present necessity to avoid future disaster. people have yet attempted to realise what a genuine

Photo shows second growth Redwood, growing from old stump.

ber famine would mean, and it must be sufficient now ay that it would strike at the very root of national gress. This disaster we can avert by tree-planting on ational scale."

The primary object of the NEW ZEALAND RED- OD FORESTS, LTD., is to replace the diminishing plies of indigenous timbers with a rapid-growing forest , which is probably the best timber tree in the world. s tree is known as the Californian Redwood (Sequoia pervirens).

Redwood Prospects.

The growing of Redwood in New Zealand is not an eriment. Plantations and individual specimens through- the Waikato and Rotorua district illustrate the nomenally rapid growth that this tree makes on niceous soils. These soils have been declared by com- nt authorities to be the most suitable in New Zealand producing rapid growth and high quality timber. *ts grown on these pumice lands will mature earlier than any other part of the world and produce a large per- age of heartwood, which, of course, is the most valuable* le of timber.

A regular and abundant rainfall is also important in ducing these results. The average annual rainfall in the rict where the Company's property is situated, has been 0 inches for the last 35 years.

orestry Experts' Views on Redwood.

"Californian Redwood, where it will grow well, sur- es every tree now in New Zealand, native or intro- d."—SIR DAVID HUTCHINS N.Z. Forestry, Part I.

MR. MAXWELL, of Rahotu, one of our best-known iters, has stated that Redwood—"the only tree that take the place of the Kauri in the finer class of timber" ill attain a diameter of 12 inches in 12½ years, which ractically a growth of one inch in diameter per annum. the Kauri takes about fifty years to grow to a diameter 12 inches, the difference in favour of the Redwood is ply enormous.

MR. D. T. MASON, of Portland, Oregon, recognised the leading authority on Redwood Deforestation and restration, says:—"Redwood standing timber is con- red worth about three times as much as Douglas Fir egon Pine). The Pinus Radiata is not considered a ber tree at all on the Pacific Coast, and has no definite ket value, so it cannot be compared with the other ies just named. I should say that under present ditions Redwood stumpage is worth at least four or times as much as the Pinus Radiata would be worth t were cut for lumber." (As previously stated, the wing of Pinus Radiata has already proved conclusively be a profitable business in New Zealand. Mr. Mason's ement quoted above, indicates how much more profitable growing of Redwood will be.)

Even more striking testimony in favour of the Redwood applied by the Rev. J. H. Simmons (one of the fore- st forestry experts in New Zealand), who points out t Redwoods planted at Whakarewarewa in the State plantations have made in the first 13 years an annual growth of one inch in diameter and five feet in height. Such facts as these seem fully to confirm the statement often made in America that *the Redwood is the most valuable timber tree in the world*. And there is no doubt that in the pumice country, which Mr. Simmonds himself has described as the best possible locality for plantations of both Softwoods and Hardwoods, the Redwood can out-strip even the Pines and Eucalypts in productivity and rapidity of growth. A glance at the large photograph on this page of a Redwood plantation only 30 years old is enough to justify this assertion.

Redwood now sells at Higher Price than Kauri.

Redwood timber is of an even, uniform texture, shows a minimum of knots and other defects, and is almost immune from decay and the ravages of insect pests. For all these reasons Redwood is selling to-day at a very high figure. Clear grades of the timber fetch 65/- per 100 super. feet on the Auckland Market, which is higher than first-class Totara or Kauri.

But, apart from its splendid timber qualities, and its consequent high market value, it possesses, from the stand-point of forestry, two other remarkable virtues: *it is practically immune from destruction by fire, and has an extraordinary capacity for reproduction.*

It is a remarkable fact that the area of the great conflagration in San Francisco, in 1906, was fringed in places with unburned Redwood houses and railway freight sheds. Literally a wall of Californian Redwood structures stayed the further sweep of the fire! Could faith in the slow-burning quality of Redwood be expressed more strongly or more strikingly than in the following resolution by the Building Committee appointed by the Mayor of San Francisco to take up the question of housing following the great conflagration:—

"Resolved, that no permits shall be given at the present time for the construction of any buildings in San Francisco, but owners of property will be allowed to proceed and erect upon their premises one-storey buildings constructed of galvanised iron or *Redwood*, without a permit."

As the Redwood is thus virtually safe during the period of its growth and is able to reproduce itself if necessary for some generations in succession, the expenditure upon Redwood Plantations cannot be regarded as speculative, but as an investment of the safest and best assured class.

Redwoods growing near Te Awamutu, N.Z., about 30 years old. This plantation has received no attention since planting. Some of the trees in the photo have a circumference of 9 feet and are over 100 high. The estimate of the N.Z. State Forestry Service of this plantation is at the rate of 158,000 superficial feet of sawn timber to the acre. On a basis of 15/- per 100ft. the timber on this plantation would yield £1185 per acre.

Security of Investment and Profits.

One of the many advantages enjoyed by the New Zealand Redwood Forests, Ltd., is the acquisition of a large area of land in the Putaruru District, admirably adapted for growing Redwood and Eucalypts. This property possesses unique railway facilities, which will necessarily mean a great saving of cost in handling, and a corresponding increase in royalty value, as compared with the returns for timber grown on more remote and less favourably situated land.

It is the intention of the Company to plant and maintain, until the timber is ready for marketing, one acre of land for each debenture issued. It is estimated that the net profit, leaving the original amount invested intact, will be from *£500 to £1,000 on each £35 debenture issued by the Company.*

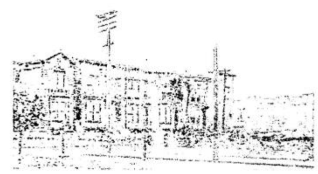
In view of all these facts, it may fairly be claimed that intending investors have here a proposition that lies entirely outside the realm of speculation.

It should be clearly understood that the *security* of the investment is one of the most attractive features. Real property in the form of land, especially when well situated on main roads or railways—as in the present case, where the facilities are ideal and unique, is universally and rightly regarded as the best kind of security. Here we have land already proved to grow trees rapidly. It is to be planted with a great crop of the best timber trees in the world: and the whole undertaking will be managed and administered by a number of the most experienced timber men in the Dominion.

The high value of the trees—Eucalypts in the early stages, and Redwoods later on—will ensure a great financial profit, while the land, in any case, still remains a permanent asset constantly increasing in value.

A Permanent Christmas Gift for the Children.

Apart from investors who look for great appreciation in the capital value of their investments, this new enterprise offers parents a splendid opportunity of buying on a small deposit and subsequent easy terms a permanent Christmas Gift, which in 25 to 30 years should be worth ten to twenty times the original cost.



These Redwood frame dwellings at Twentieth and Mission Streets, were scorched but refused to burn, thus preventing a further spread of the big San Francisco conflagration of 1906.

Young people between the ages of 20 and 30 who invest in Redwood Forests, may regard it as an assurance which will render them independent in later years.

No form of insurance offers such attractive features, and it is from this point of view that the enterprise makes a special appeal. Although the full measure of profits would not be realised till the maturity of the forests, there would at all times be a surrender value of shares which would equal the original investment plus from 8 per cent. to 12 per cent. compound interest. As the trees grow, so will the debentures steadily rise in value. *In ten years, debentures (which will be listed on the Stock Exchange) should be worth at least from £50 to £75 each, and in 20 years at least £150 to £250 each,* the price depending largely on the constantly increasing value of timber.

In concluding, we would ask readers to reflect on the outstanding advantages of this particular enterprise, when looked at in the light of an investment. At the most conservative estimate, the returns will be phenomenal when compared with other forms of investment, while the security is undoubted.

Complete information regarding the project is contained in the Company's Prospectus.

Fill in the Coupon below, and the copy of the Prospectus will be sent to you POST FREE.

THE SECRETARY, NEW ZEALAND REDWOOD FORESTS, LTD.,
NATIONAL BANK BUILDING,
FORT STREET, AUCKLAND,
NEW ZEALAND.

Dear Sir,—Please post me free copies of the Prospectus of the New Zealand Redwood Forests, Ltd., and the interesting booklet, "Fortunes in Forests."

Name..

Address..

Appendix Five: Scion Analysis Report, 2023 - NIR Sampling.

Te Papa Tipu Innovation Park,
Tītokorangi Drive, Rotorua
Private Bag 3020, Rotorua 3046,
New Zealand

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www.scionresearch.com

NIR Durability Analysis of Coast Redwood Increment Cores
October 2023

Steven Dovey
John Lee
Armin Thumm
Russell McKinley
Serajis Salekin
Toby Stovold

Summary:

In this study, 230 wood samples were processed for mass loss estimation using Near Infrared Spectroscopy (NIR) spectroscopy and wood density was measured. Durability (as a mass loss range) was estimated using a predictive model. Results show variation in mass loss and basic density across sample sets. Some limitations, such as small core sizes and the inclusion of older trees in the dataset, affected the reliability of the results and indicate a need for further investigation and improvement.

Methods

There was a total of 230 samples processed for NIR spectroscopy and wood basic density (Table 1). These are presented in the order they were received for processing according to assigned NIR batches.

Mass loss was estimated through the application of R-based partial least squares regression (PLS) modelling on Near-infrared spectroscopy (NIR) scans of the core samples, following the procedures detailed in Meason et al. (2017). Flat surfaces created on the transverse faces of each core were scanned to measure diffuse reflectance NIR spectra ranging from 800 to 2700 nm. The predictive model developed in Meason et al. (2017) for trees aged 13-87 years was used to estimate the likely mass loss based on 25 x 25 x 50 mm blocks exposed to white rot *Trametes versicolor* (L.) Lloyd (strain CTB 863 A) under controlled experimental conditions. Most trees used in model development were relatively young (comprising 80% of the sample set), with the remaining trees in the older age group. Due to insufficient age-specific data, calibrations for predicting new samples were based on the entire dataset, rather than age-specific information.

Wood density of the cores was also analysed, using the maximum moisture content method of density measurement (Smith 1954).

Table 1: Redwood increment cores submitted for mass loss estimation.

File Name Received	Region	Location	Age	Samples
28_04_2023	**East Coast**	Eastwood Hill	73	30
		Knapdale 1997	26	
		Te Puia 1930	**93**	
		Waerenga-o-Kuri 1998	25	
		Wharerata 1977	46	
Amberly_May23	**N Canterbury**	Amberley	18	14
LongMile17-04-23	**Bay of Plenty**	Long Mile, Rotorua	13	35
Redwood23_01 March_23a	**Nelson**	Appleton	16	
		Mt. Heslington	**12**	56
05_15_23	**Bay of Plenty**	Kaharoa, Rotorua	86	36
		Paradise Valley, Rotorua	**90**	
		Welcome Bay, Tauranga	26	
Conway-Wenita	**Canterbury**	Homebush	**100**	34
	N Canterbury	Conway	15	
	Wenita	Wenita	37	
Hodgson-Tirua	**Coromandel**	Tairua	**93**	
	Waikato	Hodgson	34	13
TeWera-Waipuna	**Taranaki**	Te Wera	66	12
	Waikato	Waipuna, Huntly	17	

Results

Sample limitations

Some sampling parameters limited the ability to achieve consistent results. The core size was too small (10mm) for Homebush, Conway, and Wenita. This necessitated a change in detector setup, which potentially lead to erroneous readings when using the existing calibration. The predicted mass losses for these 3 samples sets are relatively low (as indicated in Figures 1 and 2, Table 5). It is not possible to differentiate whether this is indeed a reflection of the lower mass loss of these sample sets, or whether this is an offset caused by the change in detector setup. Core samples should maintain a consistent size of 12mm for reliable results using the calibrated methods.

Certain samples represent trees that are older than the oldest trees used to develop the calibration, thus falling outside the reliable calibration range (Table 1). Since the older trees in the calibration data form a small portion of the calibration dataset, it is not feasible to use them as a separate older tree calibration. The model needs to be improved by adding an adequate quantity of samples to extend the calibration range for older trees. The results for these sites can still be useful for ranking within the site, but they should not be used for inter-site comparisons. This may require resampling using standardized methods and/or extending the calibration range. Long Mile, Rotorua samples are a further example of tree samples from the younger end of the calibration range. These cores had proportionally less heartwood with a correspondingly higher prediction decay and lower mean density.

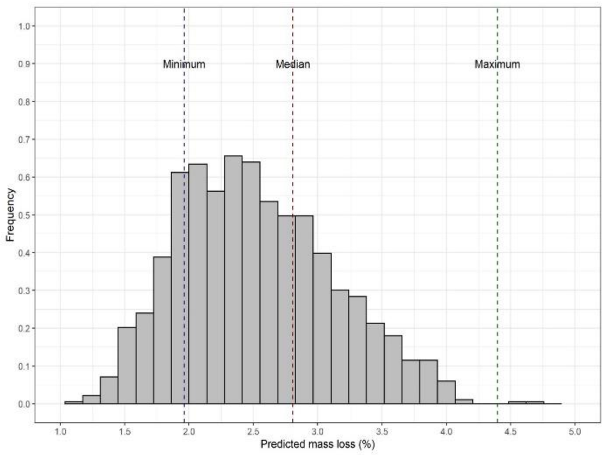
There are also a few core samples that were in poor condition, hence produced unreliable results. These are commented on as broken, mouldy or at positions near tree knots in the data Tables 2 to 8. The predicted mass loss and wood density of each sample is reported in Table 2.

To this end, any additional information on the trees from which cores were taken is useful for interpretation of the results.

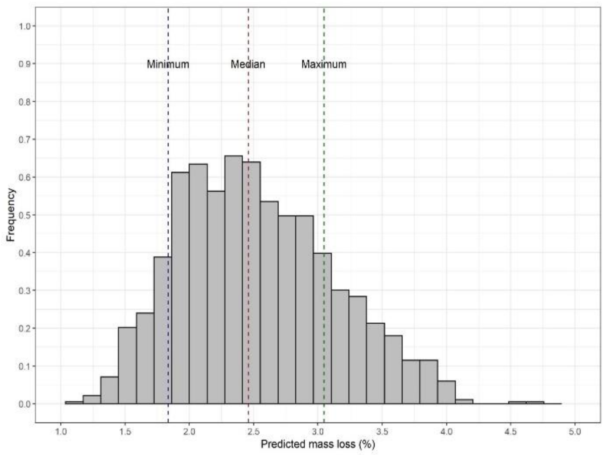
Mass loss and basic density

Mass loss for the remaining cores fell within the calibration range (Figures 1 & 2).

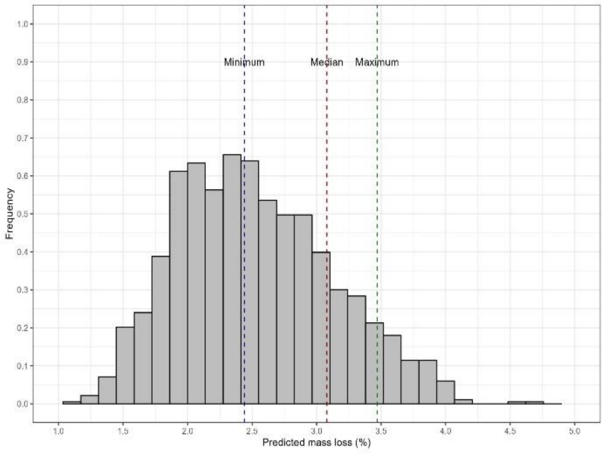
The submitted core samples had a mean basic density across all cores of 315 kg m^{-3} from the pith to the bark, ranging from a minimum of 232 kg m^{-3} to a maximum of 445 kg m^{-3} (Figure 3). The standard deviation of density samples was 40 kg m^{-3} across all sites.

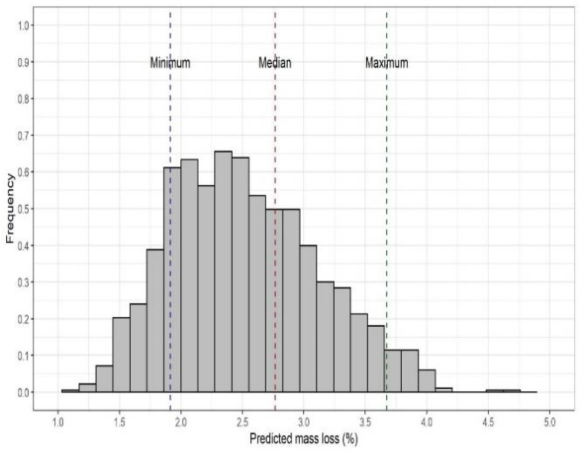


28_04_2023 East Coast



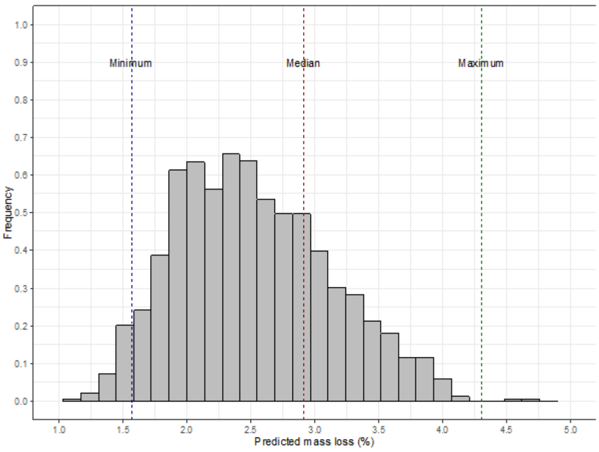
Amberly_May23 N Canterbury

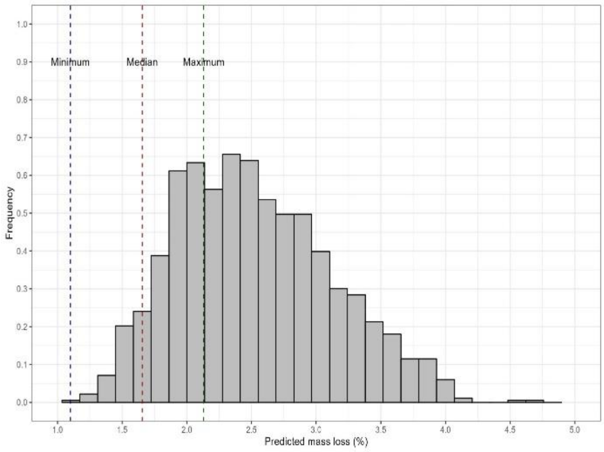




Redwood23_01 & March_23a Nelson

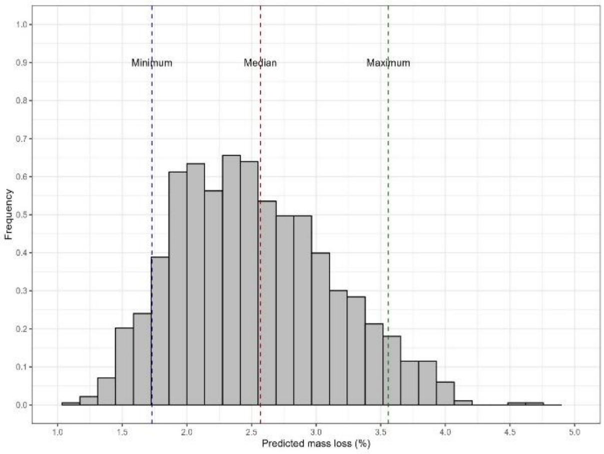
LongMile17-04-23

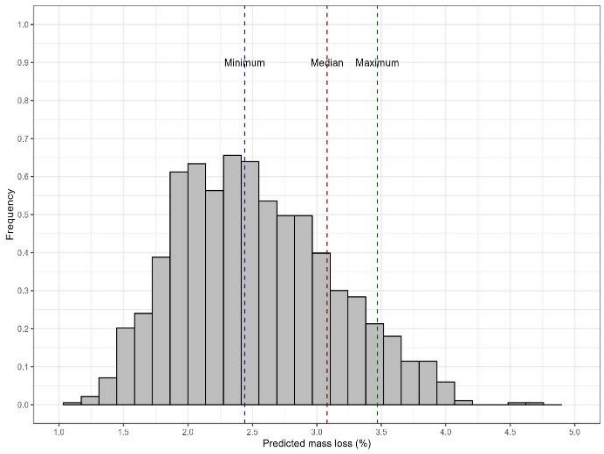




05_15_23 Bay of Plenty

Conway-Wenita





Hodgson-Tirua

TeWera-Waipuna

Figure 1: Minimum, median, and maximum predicted mass loss of submitted increment core samples for each sample set in comparison to the distribution of the original model calibration data (grey bars).

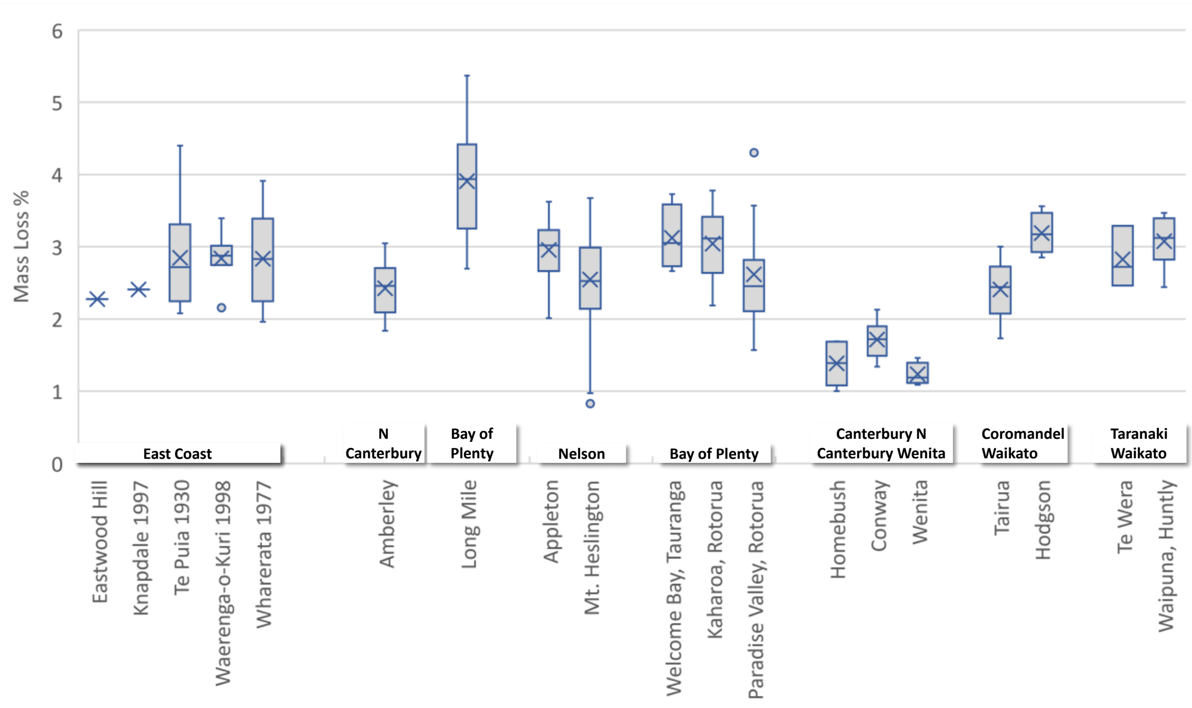


Figure 2: Box and whisker chart of predicted mass loss of submitted increment core sample sets showing the distribution of mass loss, highlighting central tendencies, variability, and potential outliers

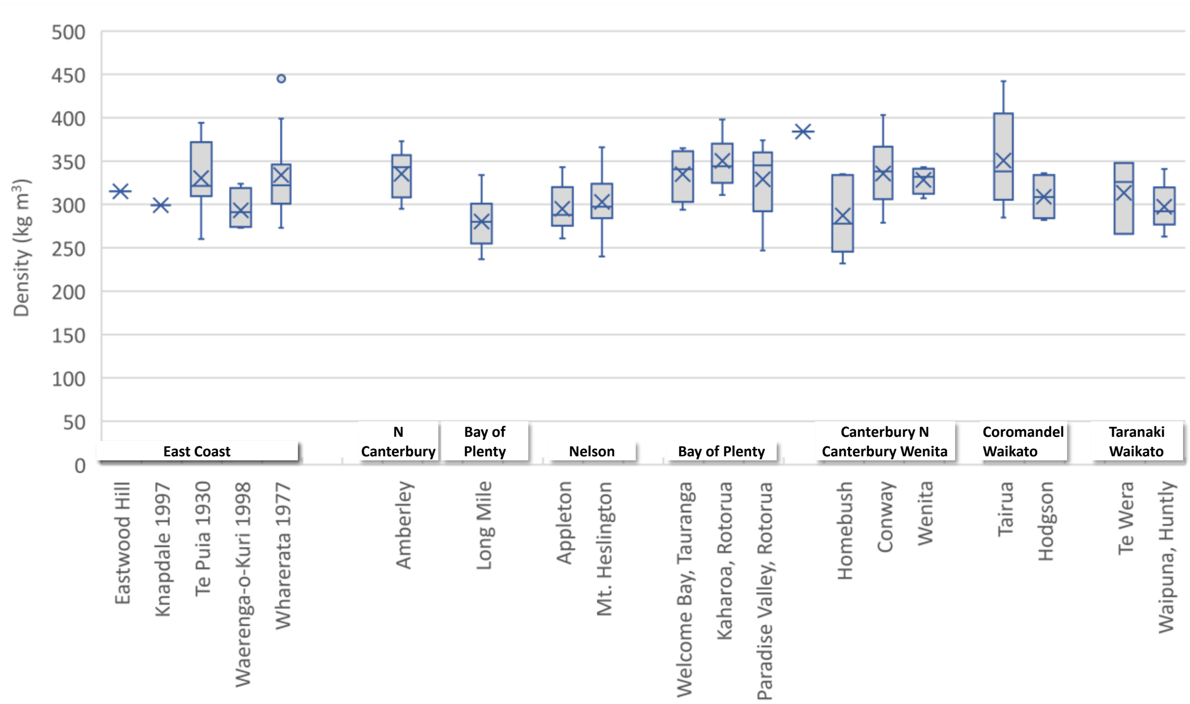


Figure 3: Box and whisker chart of basic density of submitted increment core sample sets

Table 1: Predicted mass loss and wood density of submitted redwood increment cores for samples March_23a and RedWood123.

Sample ID	**Predicted mass loss (%)**	**Basic density**	**Comment**
	Nelson		
Appleton			
1_3	2.01	307	
10_1	3.24	289	
10_1	3.04	280	
15_1	3.50	330	
15_2	2.99	323	
17_2	2.91	264	
26_1	3.62	321	
44_1	3.37	281	
7_2	2.73	311	
9_2	2.87	317	
91	2.64	321	
ap1	2.64	265	
ap2	2.49	261	
ap4	3.30	274	
b7_12	3.01	287	
h17_1	3.02	281	
h22_1	3.15	285	
h26_2	3.05	343	
h28_1	2.26	264	Missing sapwood
h32	3.21	298	
Mt. Heslington			
121	2.99	305	
121	2.60	337	
125	2.65	312	
125	1.96	310	
14	0.83	327	
14	0.97	346	
16	2.14	334	
3	2.10	315	
3	2.16	325	
3	3.13	366	
36	2.47	289	

36	2.54	319	
4	3.01	285	
40	1.94	299	
40	3.67	294	
46	2.74	283	
46	2.51	306	
53	3.57	287	
53	2.17	296	
56	2.43	270	
56	3.07	284	
73	2.33	283	
73	3.26	291	
92	3.55	297	
92	2.51	298	
93	2.09	283	
93	2.80	267	
94	2.98	265	
94	1.92	291	
96	2.36	327	
96	2.06	342	
98	2.97	320	
98	2.38	341	
ap3	2.87	284	
b12	3.08	240	
h32	2.84	288	knot

Table 2: Predicted mass loss and wood density of submitted redwood increment cores for samples 05_15_23.

Sample ID	Predicted mass loss (%)	Basic density	Comment
	Bay of Plenty		
Kaharoa, Rotorua			
kw1	2.57	370	near knot
kw10	3.12	352	
kw11	3.11	398	
kw12	3.23	370	
kw13	2.19	384	knot
kw14	3.23	311	
kw15	3.35	391	
kw16	3.51	328	
kw17	3.48	331	
kw18	2.53	359	
kw19	2.49	311	
kw2	3.53	315	

kw20	3.26	**<u>445</u>**	
kw21	3.78	314	
kw22	2.70	352	missing inner rings
kw23	2.71	344	
kw4	2.95	331	near knot
kw5	2.55	329	
kw6	2.92	338	
kw8	3.11	322	
kw9	3.54	361	
Paradise Valley, Rotorua			
fg1	4.30	247	
fg11	2.24	353	
fg12	1.57	368	
fg2	2.44	360	
fg3	2.48	351	
fg4	2.11	340	
fg5	2.00	345	
fg6	2.45	292	
fg7	3.57	253	
fg8	2.82	374	
fg9	2.80	338	
Welcome Bay, Tauranga			
af860-20	2.94	365	
af861-20	3.17	351	
kw3	3.73	294	
kw7	2.66	330	near knot, mismatch

Table 3: Predicted mass loss and wood density of submitted redwood increment cores for samples 28_04_2023

Sample ID	Predicted mass loss (%)	Basic density	Comment
	East Coast		
Eastwood Hill			
ewh1	2.28	315	
Knapdale			
kn1	2.41	299	
Te Puia			
tp1	2.29	394	
tp2	3.02	386	
tp39	2.54	330	
tp50	3.48	317	
tp54	3.25	313	
tp66	4.40	299	

tp67	2.10	367	
tp68	2.90	260	
tp69	2.08	314	
tp70	2.39	325	
Waerenga-o-Kuri 1998			
wok1	2.16	291	
wok2	3.39	274	
wok3	3.01	319	
wok4	2.75	273	
wok5	2.88	298	
wok6	2.91	274	
wok7	2.79	324	knots
Wharerata 1977			
wh10	2.39	399	
wh1-1	3.91	325	
wh1-2	3.63	321	
wh2	2.20	**445**	knots
wh3	3.12	336	
wh4	2.24	322	
wh5	2.83	301	
wh6	2.58	308	
wh7	2.91	346	knots
wh8	3.39	299	
wh9	1.96	273	

Table 4: Predicted mass loss and wood density of submitted redwood increment cores for samples Amberly_May23

Sample ID	Predicted mass loss (%)	Basic density
	N Canterbury	
Amberley		
021	2.45	306
711	2.55	322
757	2.59	345
772	2.88	309
774	2.57	345
776	1.83	360
777	2.18	367
9211	1.84	341
9212	2.30	356
9213	3.05	318
9215	2.46	304
926	2.01	373

927	2.81	295

Table 5: Predicted mass loss and wood density of submitted redwood increment cores for samples Conway-Wenita

Sample ID	Predicted mass loss (%)	Basic density	Comment
	Canterbury		
Homebush			
1779	1.69	278	
1768	1.68	259	
1765	1.39	232	
1767	1.16	333	
1766	1.00	335	Very mouldy
	N Canterbury		
Conway			
002	1.69	338	
1001	1.93	310	near knot
003	1.76	389	
36	1.93	354	
029	1.84	365	
019	1.45	348	
058	2.13	279	
004	1.63	347	
7	1.34	366	Mouldy
60	1.96	308	
09	1.44	293	
022	1.70	323	
10	1.51	387	
037	1.47	375	near knot
35	1.72	281	
048	1.44	332	
30	1.59	367	
005	2.00	304	
049	1.90	383	
1003	1.90	280	
006	1.46	316	
034	1.82	280	
017	1.77	403	
033	1.63	340	
031	1.84	324	
Wenita			
9	1.46	307	
13	1.20	336	

17	1.09	343	Very mouldy
15	1.18	328	

Table 6: Predicted mass loss and wood density of submitted redwood increment cores for samples Hodgson-Tirua

Sample ID	**Predicted mass loss (%)**	**Basic density**
	Coromandel	
Tairua		
TR7	2.55	306
TR3	2.12	285
TR9	2.35	356
TR8	2.44	**442**
TR10	2.88	315
TR1	2.03	338
TR2	1.73	401
TR4	2.57	305
TR6	3.00	409
	Waikato	
Hodgson		
HSN4	2.85	336
HSN3	3.56	282
HSN5	3.15	327
HSN2	3.19	290

Table 7: Predicted mass loss and wood density of submitted redwood increment cores for samples LongMile17-04-23

Sample ID	**Predicted mass loss (%)**	**Basic density**	**Comment**
	Bay of Plenty		
Long Mile			
182	4.07	278	
411	3.70	248	
704	5.10	257	
7510	4.54	269	
755	4.42	254	
756	4.65	280	
763	4.86	290	
771	4.27	261	

774	4.30	283	
914	4.12	246	
9215	4.90	240	
923	5.37	259	
925	3.48	255	
928	3.41	237	one sample
928	4.68	257	
D01_5	3.05	306	
D02_3	3.03	252	
D02_3	2.94	254	
D08_1	3.11	285	
H02_1	3.07	299	
H04_2	3.51	301	
H09_5	3.99	318	
H10_4	3.47	322	
H11_6	3.25	294	
H13_1	3.14	330	
H14_3	4.57	306	
H15_1	3.93	284	
H19_1	3.88	334	
H5_4	3.94	279	
L01_4	4.10	276	
M02_1	2.70	303	
M05_1	3.18	283	
M05_2	4.34	248	
R02_2	3.47	293	
R02_4	4.15	331	

Table 8: Predicted mass loss and wood density of submitted redwood increment cores for samples TeWera-Waipuna

Sample ID	Predicted mass loss (%)	Basic density	Comment
	Taranaki		
Te Wera			
TW3	2.72	348	
TW1	3.29	266	
TW2	2.46	326	
Waikato			
Waipuna, Huntly			
bf2-1	3.36	341	knot
jpsm3	3.04	290	
jps1	2.44	292	
jpsm2	3.18	298	

JPS3	3.47	265	
RB54-1	2.79	263	
JPS2	3.12	289	
jpsm1	3.43	308	knot near pith
RB30-1	2.85	331	knot near pith

Literature Cited

Meason, D., Riddell, M., O'Callahan, D. and Thumm, A. (2017) Getting to the heart of Coast Redwood durability – Final technical report. Confidential Report. Scion, Rotorua.

Smith, D.M. 1954: Maximum moisture content method for determining specific gravity of small wood samples. United States Department of Agriculture, Forest Service, Forest Products Laboratory Report No. 2014.

Appendix Six: Scion Analysis Report, 2022 - NIR Sampling.

Te Papa Tipu Innovation Park,
Tītokorangi Drive, Rotorua
Private Bag 3020, Rotorua 3046,
New Zealand

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3 October, 2022

Attention: RobWebster Sequoia Action Group
C/- Russell Coker Secretary – Treasurer

New Zealand Farm Forestry Association

13 Patiki Street

Lincoln 7608

Dear Rob,

Re: NIR Durability Analysis of Coast Redwood Increment Cores

Thank you for submitting coast redwood cores for their durability analysis. There was total 61 samples submitted for near infra-red (NIR) spectroscopy and wood density analysis. Flat surfaces were created on the transverse face, and the cores were scanned to measure diffuse reflectance of NIR spectra in the range of 800 – 2700 nm. The model developed for all-ages by Meason et al. (2017) was then used to predict the likely mass loss of a 25 x 25 x 50 mm block exposed to white rot *Trametes versicolor* (L.) Lloyd (strain CTB 863 A) under experimental conditions. We also undertook analysis to determine the wood density of the cores.

The predicted mass loss and wood density of each sample is reported in Table 1. The mass loss percentage of all cores fell within the 75th percentile when compared to the calibration dataset (Figure 1). The estimated minimum, median and maximum mass loss percentages across the submitted cores were 1.32, 1.86 and 2.75 %, respectively. The data represented a total 7 different sample groups (Figure 2); however, two of these groups, namely TG and TKS, had only one sample each.

The submitted core samples had a mean basic density 313 kg/m^3 from the pith to the bark, with a minimum of just 273 kg/m^3 and a maximum of 367 kg/m^3.

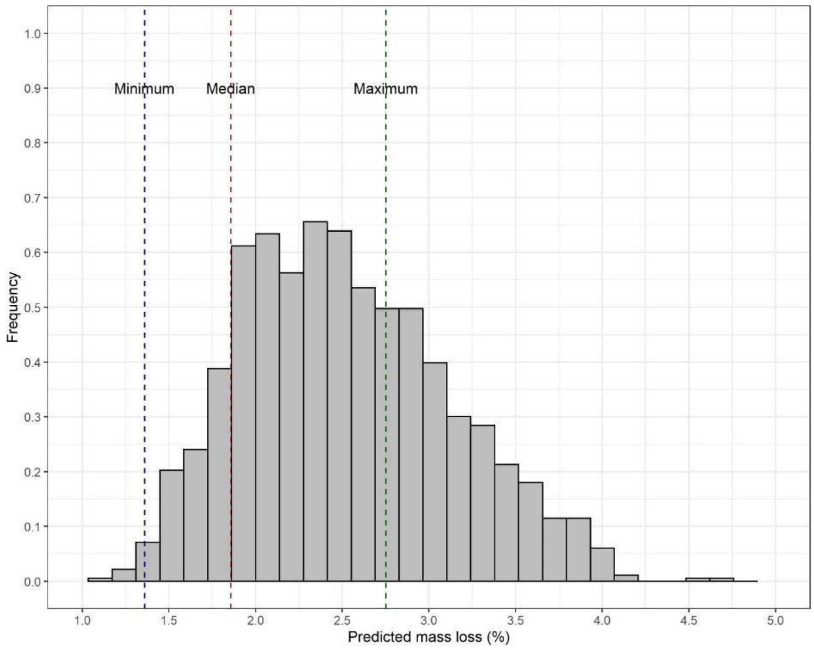


Figure 1: Minimum, median, and maximum predicted mass loss percentage of submitted increment core samples in comparison to the distribution of the original model calibration data (grey bars).

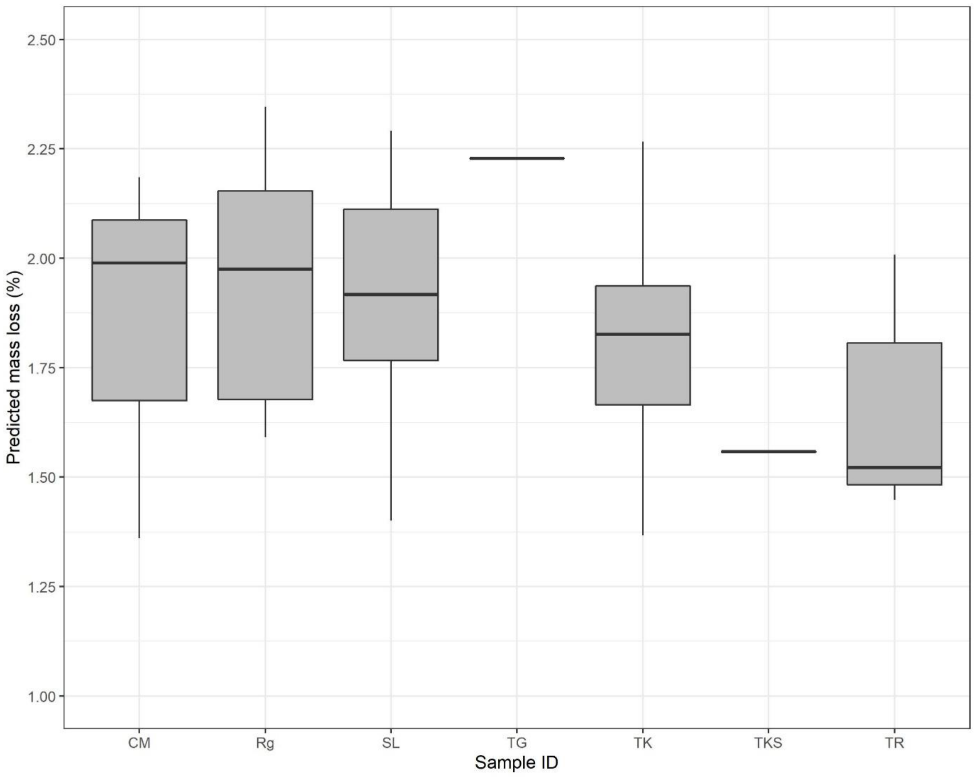


Figure 2: The predicted mass loss of submitted increment core samples by sample group. The upper and lower boundaries of the box indicated the upper and lower quartiles of each sample, respectively. The two ends of whisker indicated the upper and lower extreme within each sample, respectively. The bold line within each box referred to median mass loss percentage, two sample has only one core to measure (i.e., TG, TKS).

Table 1: Predicted mass loss and wood density of submitted coast redwood increment cores.

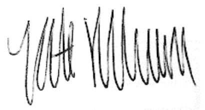
Sample ID	Predicted mass loss (%)	Percentile of predicted mass loss	Pith-to-bark Basic density (kg/m3)
CM013	2.18	35	319
CM043	1.99	25	323
CM08S	1.36	2.5	285
Rg01	1.99	25	321
Rg02	2.35	40	280
Rg03	1.61	5	312
Rg04	1.59	5	319
Rg05	2.23	35	285
Rg06	1.96	25	279
Rg07	2.14	30	307
Rg08	1.67	10	300
Rg09	1.68	10	327
Rg10	2.11	25	286
Rg11	1.90	15	365
Rg12	2.20	35	311
SL1	1.67	10	342

SL2	1.93	20	286
SL3	2.19	35	297
SL4	1.94	20	274
SL5	1.76	10	302
SL6	1.79	15	284
SL7	1.91	20	340
SL8	1.40	2.5	323
SL9	1.71	10	349
SL10	2.29	40	332
SL11	2.75	75	351
SL12	2.24	40	288
SL13	1.79	15	286
SL14	2.12	30	277
SL15	2.08	30	279
TG01	2.23	35	318
TK01	2.27	40	273
TK2	1.69	10	327
TK3	1.46	2.5	333
TK04	1.66	10	367
TK5	1.52	2.5	337
TK6	1.80	15	277
TK7	2.02	25	321
TK8	1.74	10	320
TK09	1.37	2.5	303
TK10	1.88	15	326
TK11	1.65	10	300
TK12	2.12	30	347
TK13	1.77	10	300
TK14	1.90	20	316
TK15	2.00	25	342
TK16	1.85	15	316
TK19	1.86	15	308
TK55	1.95	20	324
TKS8	1.56	5	283
TR01	2.01	25	308
TR02	1.45	2.5	354
TR03	1.95	20	307
TR04	1.89	15	301
TR05	1.72	10	317
TR06	1.49	2.5	323
TR07	1.52	2.5	355
TR08	1.48	2.5	327
TR09	1.45	2.5	319
TR10	1.48	2.5	354
TR11	1.56	5	290

Literature Cited

Meason, D., Riddell, M., O'Callahan, D. and Thumm, A. (2017) Getting to the heart of Coast Redwood durability – Final technical report. Confidential Report. Scion, Rotorua.

Regards



Yvette Dickinson
Silvicultural Scientist, and Portfolio Leader for Designing Forests - Mahi Tahi Whaihua