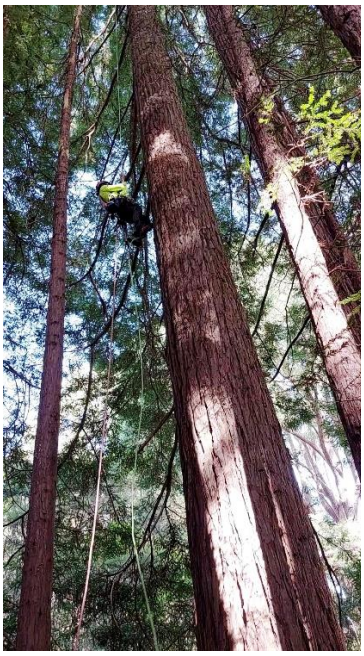
Diversified Forestry Project

of the

Forestry and Wood Processing Industry Transformation Plan:

Final report



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Contents

Executive summary

This Diversified Forestry Project has enabled a range of projects focusing on alternative exotic species – the species needed if New Zealand's forest industry is to diversify away from the current radiata pine near-monoculture. The project outputs provide preliminary data and information ahead of a potential larger, long-term programme to grow confidence and de-risk investment in diversified species.

A total of 15 sub-projects were funded under three workstreams:

1. Barriers to entry
2. Seed collection/germplasm archiving
3. Inventory and adding value.

The project teams involved in the 15 sub-projects included a wide range of specialty species experts, including research scientists and practitioners – growers, saw-millers and forestry consultants. The project has enabled a number of important gains to be made and questions to be answered. More importantly, it has added to the foundations laid by the Specialty Wood Products Research Partnership towards a new, longer-term diversified forestry research and development programme.

Some of the high-level progress in each of the three workstreams is summarised as follows:

1. Barriers to entry

- The value of bioeconomy in New Zealand was estimated at $12-$19 billion. This demonstrates huge potential for further product streams from forests.
- Durable eucalypt plus-trees were selected to further advance breeding work, meaning better tree stocks for growers in future. Further wood property data was also collected to heartwood quality and quantity is acceptable.
- Pest and disease risks in durable eucalypts are now better understood. This reduces the chances of plantation losses and increases grower confidence.
- Poplar plantings in NZ were documented, and the NZFFA Poplar Action Group formed to increase momentum in poplar breeding, growing and utilisation.
- Durability data has been added to the alternative species database. Durability classes are needed to determine what applications timber can be used for, so this new information will assist in encouraging the use of alternative species in building projects.
- Thirty-eight coastal redwood (*Sequoia sempervirens)* trees identified across 11 sites will be targeted for collection of mature budwood to contribute to a clonal archive and seed orchard. These superior trees will be included in future breeding programmes.
- An 8-year-old cypress hybrid clonal trial was thinned, and sample logs delivered to Ruapehu Sawmills, where they have been sawn into 100 x25 mm boards and placed in fillet to be seasoned for strength testing.
- It was found that some provenances of Abies grandis have higher fertility than others. This is where the focus will be for future seed collection work. Different provenances responded differently to light levels after germination.

2. Seed collection/germplasm

- Seed from a diverse range of exotic alternative species was collected and will be stored at Proseed NZ to provide security and capacity for future demand.
- Twelve kilogrammes of durable eucalypt seed was collected. This could produce over 800,000 first-grade plantable seedlings.

- 12.2 kilograms of coastal redwood seed was collected. This could produce over 85,000 first-grade plantable seedlings.

3. Inventory and adding value

- Key factors driving timber imports and barriers to using New Zealand-grown timber supplies at scale were identified and can begin to be addressed.
- A remote sensing approach was further developed to classify alternative species. It estimated substantially more hectares of eucalypts, Douglas-fir, and cypress in the Wairarapa than indicated by the National Exotic Forest Description.
- Top-performing cypress clones were identified and will be used as a source of material for establishing stoolbeds for bulking up for deployment and further trials. This will allow the top clones to be made available to growers.
- A range of wood and wood products from New Zealand-grown alternative species were used to build a strong, sustainable two-roomed demonstration cabin.
- Durable eucalypt growth measurements show that selection and site-species matching have resulted in significant relative growth increases. This demonstrates the benefits of NZDFI's breeding programme and increases confidence in site/species matching.
- Remeasuring 171 existing permanent sample plots (PSPs) in alternative species and establishing 85 new PSPs will provide valuable data for current and future growth models, health assessments and species and hybrid comparisons.

Overall, a great deal has been achieved in a short timeframe by the 15 project teams and many valuable advances made. The challenge now is to communicate the findings of the project and ensure relevant results are built upon in future diverse species research and development work.

Workstream 1: Barriers to entry

Aims/objectives

This workstream aimed to develop future markets and mitigate barriers to entry of specialty species by collating, adapting and sharing existing knowledge on specialty wood products performance, supply chains, and the social, economic and environmental benefit of specialty wood sectors and products.

Activities supported included measuring field trials, collecting wood samples, screening for key wood properties, and testing timber products.

Outputs

1. Bioproducts from New Zealand forests

The potential value of bio-products from New Zealand forests was examined. New Zealand has the potential to develop a profitable, sustainable bio-products industry from forests. Such an opportunity would require investment, changes to government policy and a rethink of the current forestry sector structure but has the potential to lift forestry sector exports by $12 - $19 billion. The potential new products are bio-chemicals, biomaterials and biofuels, and their production would occur alongside the traditional wood products produced from forests. The government will be a critical enabler for a bio-product forest industry, through both policy and non-policy measures.

2. Durable eucalypts

Six reports were delivered under this workstream for the *Eucalyptus macrorhyncha* and assessment of class 1 durable eucalypts project.

i. Over 600 *E. macrorhyncha* trees were assessed and 19 plus-trees were selected for candidates for seed collection (see Figure 1). This will ensure that the seed collected comes from the best possible trees leading to planting stock that will grow the most valuable trees.

Fig 1: 18-year-old E. macrorhyncha plus tree selected for seed collection in Marlborough.

ii. A workplan to support an active *E. macrorhyncha* breeding programme (trials) and identifying new elite genetic material (seed sources) was developed. This is key to help reduce the barriers to entry to planting these species by supplying the highest quality genetic material for growers.
iii. *Eucalyptus macrorhyncha* pest and disease threats were reviewed. Field observations suggest that this species is one of the least preferred host species for the paropsine beetles (*Paropsis charybdis* and *Paropsisterna cloelia*) which can both be destructive to trees through leaf browsing. Having a species that is less susceptible to damage by these pests helps give confidence to growers to plant durable eucalypts.
iv. A workshop to rank research and development priorities for *E. macrorhyncha* and three other class 1 durable red eucalypts was held.
v. *E. macrorhyncha* and *E. tricarpa* have shown good growth and site adaptability and are candidates for genetic development. Further investment in testing the wood properties of *E. tricarpa* in the breeding population is recommended. Conversely*, E. argophloia and E. longifolia* were generally less adaptable and productive with poor stem form across the 19 trials. No further investment is required other than remeasurement of the PSPs every 3 – 5 years.
vi. *E. macrorhyncha* is a species related to E. globoidea but more tolerant of colder climates. The opportunity to expand NZDFI's programme to colder sites with E. macrorhyncha, also depends on its wood properties. Assessments of *E. macrorhyncha* wood properties from the NZDFI Waikakaho seedling seed stand were undertaken. Heartwood and sapwood sizes were assessed, basic density was measured, extractive content determined, and level of collapse scored. There was generally little variation between provenances, but some potential for making gains through breeding for extractive content were seen. These results were compared to other durable eucalypt species such as *E. bosistoana* and *E. globoidea*.

3. Poplar projects

Two reports were produced on poplar describing:

i. national and international activity for poplar species and hybrids
ii. the extent of poplar plantations and timber use in New Zealand.

New Zealand climate is generally very suitable for poplars; growth rates for improved clones of hybrid poplar in New Zealand compare favourably with rates in Europe and North America. Selection of clonal types is also similar, though almost all clones now propagated in New Zealand have emerged from our domestic breeding programme. There is, however, no site suitability map for New Zealand that matches poplar species/clone with region.

To help get a co-ordinated approach, a Poplar Action Group (PAG) has now been formed by the NZ Farm Forestry Association. There is considerable interest in poplar cultivation and utilisation amongst NZFFA members. Thirty-nine people attended the launch meeting. A mailing list of 91 people has been compiled. The purpose of the PAG is to promote and support the growing, processing and marketing of poplar wood and poplar and willow for extractives, fibre and bioenergy.

Future research direction has been identified by the Poplar Action Group and it includes:

i. producing a national map matching poplar cultivars to regions and sites
ii. further evaluation of poplar timber (including Kawa and other cultivars)
iii. growth data for both plantation and spaced poplar regimes (Permanent Sample Plots)
iv. determining the extent of poplar plantations (more extensive than the preliminary survey undertaken).

The PAG will seek government and industry funding support for these initiatives.

The number of poplar and willow poles planted annually exceeds 150,000, with annual 3-metre pole sales from regional councils to landowners being around 100,000. At a planting density of 50-100 poles/ha, between 1,000 and 2,000 ha are being planted annually. People are optimistic about the future of poplar as a timber tree, but much more education about silviculture and potential uses is needed if this is to be realised.

4. Cypress and eucalypt durability tests

Two durability trials assessed the condition of stakelets and stakes of cypress and eucalypt timber.

i. The cypress test samples (*Cupressus ovensii and C. x leylandii*) have been in the ground for 2.5 years and average condition is over 7 (decay in 3-10% of cross section) while the treated radiata controls had an index of condition of only 2.6 (deep and severe decay, in over 50% of cross section). These are very promising preliminary results. This trial will continue and will be assessed annually, with the next assessment due in April 2024.
ii. Six young durable eucalypt species were assessed after 7 years in-ground. Results show that they will be at least durability class 2 (durable in ground for 6-10 years). This is an excellent result considering the trees were only 15 years-old when felled. The trial will continue until all samples fail due to decay, this is when an official average life for the species can be determined.

Long term trials like these provide key data to assist with getting species and products into the Building Code.

5. Selecting superior coastal redwood

Increment core samples from plus-trees in various coast redwood (*Sequoia sempervirens*) stands were collected (see Figures 2 and 3) to estimate heartwood durability (using near infra-red spectrometry (NIR)) and basic density. This information was used to identify trees with superior phenotypic characteristics from which budwood will be collected, propagated, and included in future breeding programmes. Thirty-eight trees across 11 sites (all older stands) have been identified that will be targeted for material to contribute to a clonal archive and seed orchard.

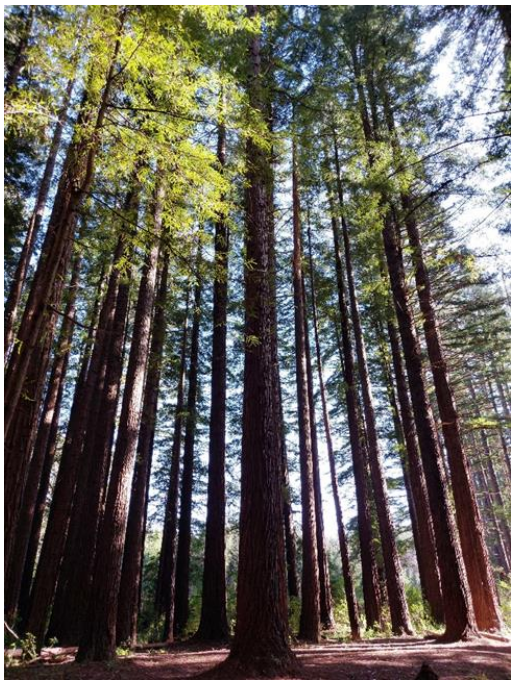


Fig 2: (right) Plus trees in Paradise Valley, near Rotorua. Fig 3: (left) Preparing to take an increment core sample in a selected redwood, Kaharoa, near Rotorua.

A recommendation that follows this work is that clonal archive material at Proseed NZ, Amberley, derived from the Rotoehu provenance trial and which does not exhibit desirable levels of heartwood durability and basic density, should be considered for deletion from future breeding programmes.

6. Identifying top-performing cypress clones

In 2011, Scion produced a series of hybrid clones with imported pollen from superior selections made from *C. Nootkatensis*, the Alaskan Yellow Cedar. This pollen was used to make hybrid crosses with the best available strains of *C. macrocarpa, C. lusitanica* and Guadalupe cypress. The purpose was to make hybrids that inferred the cypress canker resistance that is apparent in C. *Nootkatensis* and has the added advantage of renowned heartwood durability.

The best performing of the new hybrids were selected at a young age (less than five years) for their ability to strike root from cuttings. A trial was planted at Paparoa in 2015 with 30 separate clones. The trial was assessed in 2019 at a basic level by the Cypress Development Group of NZFFA. Measurements consisted of diameter and height recordings as well as visual assessments of branching architecture and any signs of cypress canker.

As part of the current project, the Paparoa trial was thinned, and sample logs were delivered from the 8-year-old trees to Ruapehu Sawmills (see Figure 4), where they have been sawn into 100 x25 mm boards and placed in fillet to be seasoned for strength testing. Minimal heartwood was apparent in the logs, so no durability testing will be possible at this young age. The project team embarked on a major rejuvenation which involved thinning of 25% of the stand and high pruning to 90mm stem diameter of the remaining trees.

Fig 4: The Paparoa cypress hybrid trial after pruning and thinning; removal of logs for sawing at Ruapehu Sawmill.

7. Potential for *Abies grandis* and other Abies species

Abies species are valuable utility softwoods with timber properties capable of substituting for radiata pine. This species has similar wood properties to Radiata pine but because it is a distinctly different species, it is not susceptible to the same pathogens. We need to develop nursery systems to grow this species at scale and if possible, to produce strong planting stock within one growing season.

Seed was collected from *Abies grandis* (grand fir) and other Abies species. Nursery trials were established to determine the optimum/productive way to raise these seedlings at scale (see Figure 5). The project aims to deliver seedlings for the wider uptake of Abies species at reasonable cost to New Zealand growers. What we now know is that some provenances have higher fertility than others. This will be the focus of future seed collection work. We also now know that different provenances respond differently to light levels after germination. Some require more shade than others to demonstrate their initial vigour when first emerging. Some require full sun.

Fig 5: Abies seedlings in trays at the nursery.

Workstream 2: Seed collection/germplasm archiving

Aims/objectives

This workstream aimed to improve the potential to up-scale alternative species planting stock production. Substantially greater numbers of plants will be needed if the area of new planting increases in line with the ITP vision (20% of all new species to be alternatives to radiata pine). The focus was on ensuring the best available genetics are used for future planting stock production.

Outputs

1. Seed banking

Forest Growers Research oversaw seed banking of a diverse range of exotic specialty wood species seed. Seed was collected from durable eucalypts, coast redwood, and stringybark eucalypts.

Best trees were selected, their location recorded, seed collected, extracted, and cleaned, and then stored as required. FGR will produce a report documenting the process and the amount of seed stored for each species. The seed will be used for establishing future seed orchards, trialling species on new sites and bulking up available plants for selected new planting opportunities.

2. Durable eucalypts

Following completion of productivity, form and wood properties assessments, elite families have been identified within NZDFI's *E. bosistoana* and *E. globoidea* breeding populations and plus trees selected within these families for seed collection. 142 seedlots were collected. Over 12kgs of seed was collected from all species (see Figures 6 and 7) and sites with an estimated potential to produce >800,000 first grade plantable seedlings. The seed will be used for seedling stands, 2nd generation progeny breeding trials, silvicultural trials and commercial deployment. All these seedlots are being held in storage by Proseed NZ for future deployment by NZDFI under the XyloGene brand should there be demand.

Fig 6: (left) Collection being made from an 18-year-old E. macrorhyncha plus tree in MRF Waikakaho trial, Marlborough. Fig 7: (right) Collection being made from a 12-year-old E. globoidea plus tree in Atkinson trial, southern Wairarapa.

3. Redwood

The project on coastal redwood (*S. sempervirens*) seed identified superior trees for growth and wood quality (heartwood of higher-than-average durability). A number of trees were either climbed (see Figure 8) or seed was collected with nets or from the ground. A total of 68.8 kgs of redwood cones was collected, with 12.2 kg seed produced from trees identified as plus trees (growth and heartwood quality). Seed will go to nurseries to establish trials and be marketed to redwood growers. This seed has already produced over 50,000 plantable seedlings and current estimate is that this seed will produce approximately 85,000 plantable seedlings in total.

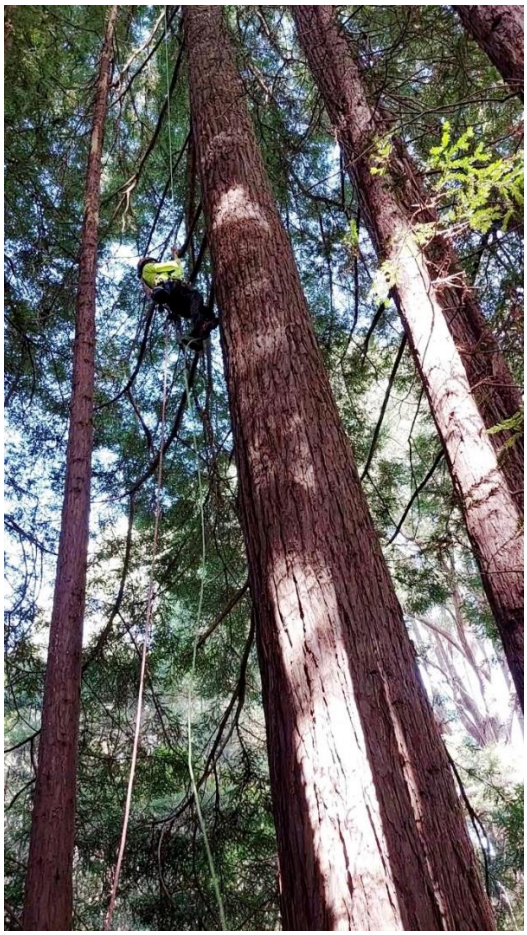


Fig 8: An arborist climbing a redwood tree to collect seed.

4. Non-durable eucalypts

The 'Eucalypt seed collection for improved genetics' project has not been completed yet, as seed is not ready for harvesting until December-February, when it will be collected.

This project was fully funded by the Small to Medium Enterprise (SME) committee and will be completed in summer 2023-24.

Workstream 3: Inventory and adding value

Aims/objectives

The workstream aimed to extract additional value from the approximately 70,000-hectares of existing specialty species growing in New Zealand through description, measurement, sampling and evaluation.

Outputs

1. Import substitution study

A study into the import substitution of a long-term diversified forestry programme identified specific wood products and product lines, currently imported to New Zealand, that might be successfully substituted by NZ grown wood and wood-based products.

There are currently three major concerns around importing and using imported timbers:

- importers rely on old-growth tropical timbers, which may not be sustainably harvested, or which may be more difficult to source in future (see Figures 9 and 10)
- increasing volumes of imported timbers are entering the domestic market, particularly in the decking, flooring and furniture markets
- exported New Zealand -grown radiata is being re-imported into New Zealand in the form of higher-value products.

To address these concerns, timber importers and timber designers (architecture and furniture) were asked about their requirements which drive the use of imported timber. The aim was to determine:

- What is the current specialty timber resource base within New Zealand?
- Current species in the ground and being harvested
- Imported timbers or finished goods available for use in building projects
- What timber species are being imported, and why?
- How are architects and designers selecting timbers for projects?

Results show the key factors driving timber imports are consistent and reliable supplies, short lead times for projects, dedicated sales agents, proven or known performance of the timber for the application, and an ability to provide a range of aesthetics (stains and surface treatments).
In contrast, the barriers to using New Zealand-grown timber supplies at scale include unknown current and future wood supply, unproven or inconsistent wood quality, lack of central marketing or sales support agency, and lack of clarity on how to source (by specifiers) or supply (to end users) the timbers.

To substitute current imported species with New Zealand-grown specialty timbers will require:

i. improved mapping of the New Zealand-grown resource to provide future in-ground estimates of timber availability
ii. establishment of a dedicated ‘sales desk’ advocating timber species and products, arranging New Zealand-grown specialty timber samples for supply chain visibility, and accessibility to local market
iii. a change in the way information concerning New Zealand-grown specialty timbers is presented to specifiers

modification of a selection of specialty timber species to improve wood properties for use (e.g., densification, thermal modification etc.).

Key policy barriers are apparent - for example the difficulty for small growers and processors to gain FSC certification. There is also a distinct lack of supply chain integration through from growers to specifiers, and a low sawmill conversion or grading segregation to separate processing pathways. There are several options to approach a more aggregated regional specialty wood solution. As a start, *E. saligna* decking for Northland processing has been identified from the work, which should be proposed back to the sector and further explored through meetings with people in the industry.

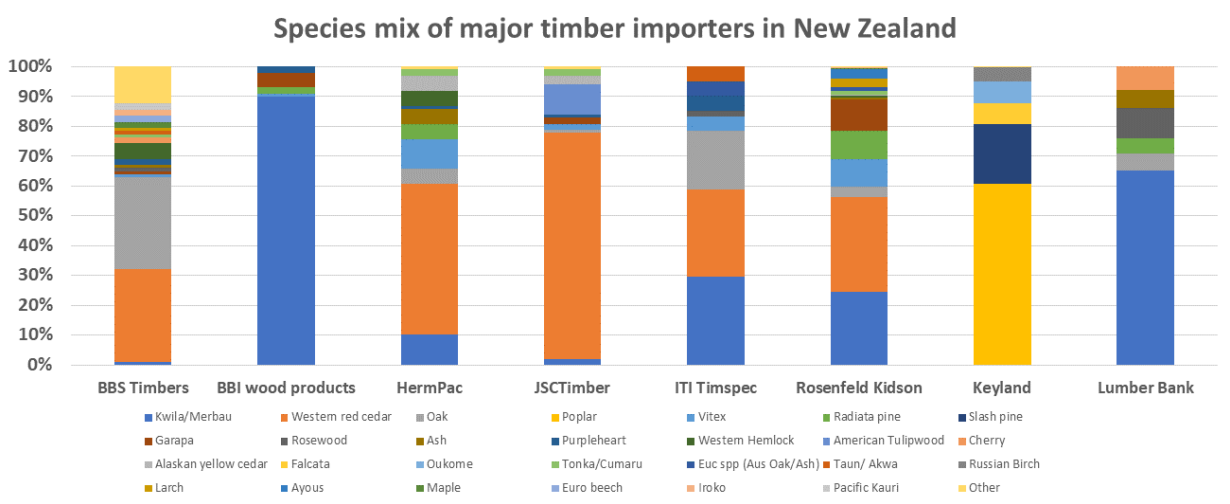


Fig 9: Timber imports – species product mix for each of the larger timber importers.

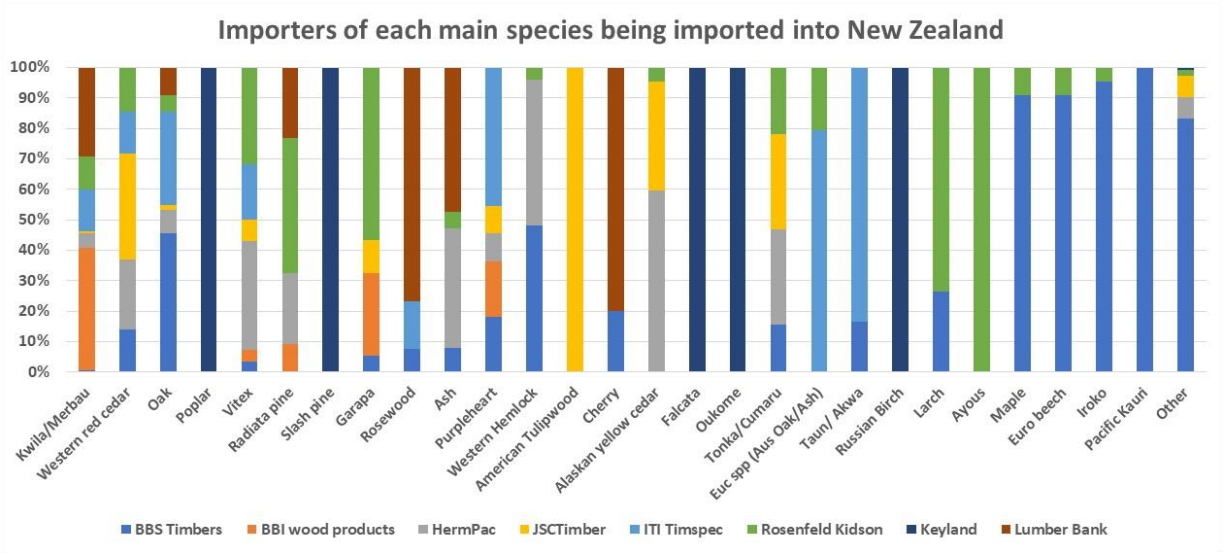


Fig 10: Timber imports by range of suppliers per species.

2. Mapping alternative species in the Wairarapa

A species mapping project applied a remote sensing approach developed by the School of Forestry to classify alternative species in small-scale plantations in the Wairarapa region. Similar to previous projects, the approach achieved an overall classification accuracy of 92.9%. Douglas-fir and Eucalyptus appeared as the two most accurately classified alternative species classes. The key input

variable selected for classification was the Digital Elevation Model (DEM), indicating that elevation significantly influences the differentiation of plantation species.

A total of 1,617 hectares of alternative species were mapped (see Figure 11), with Eucalyptus being the most prevalent species class, constituting 35% of the total alternative species resources. Other species, including mixed species and less common alternatives, accounted for 24%. In comparison to the National Exotic Forest Description (NEFD) report, there was a notable difference of 453 hectares (17%) more than the NEFD-reported area. This study estimated substantially more Eucalyptus, Douglas-fir, and cypress than indicated by the NEFD. The Wairarapa NZFFA branch will undertake the ground truthing exercise on this project in the New Year. This will check on the preliminary mapping component as well as the algorithm species classification.

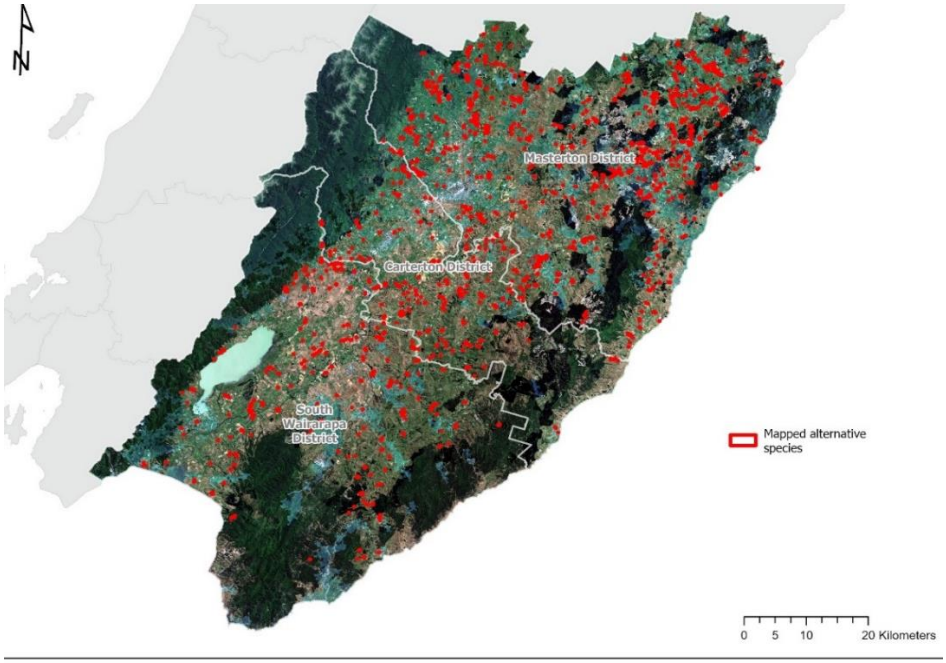


Fig 5: Locations of alternative species mapped in the Wairarapa.

3. Assessing hybrid cypress trials

In 2017 trials were planted to evaluate potential new cypress hybrids derived from crosses made in 2012. The new hybrids were deployed as untested clones, along with 30 tested hybrid clones from a previous round of crossing. Three of the trials (Pipiwai, Kaingaroa and Tarawera) had small partial assessments in 2020/2021 which identified some clones growing well, but with limited data there was a desire to return, complete full assessments, and gain a more comprehensive dataset from which to select the best performers. The Tarawera site has now been assessed and a group of well-performing clones was identified to be established as stoolbeds for bulking up for deployment and additional trials.

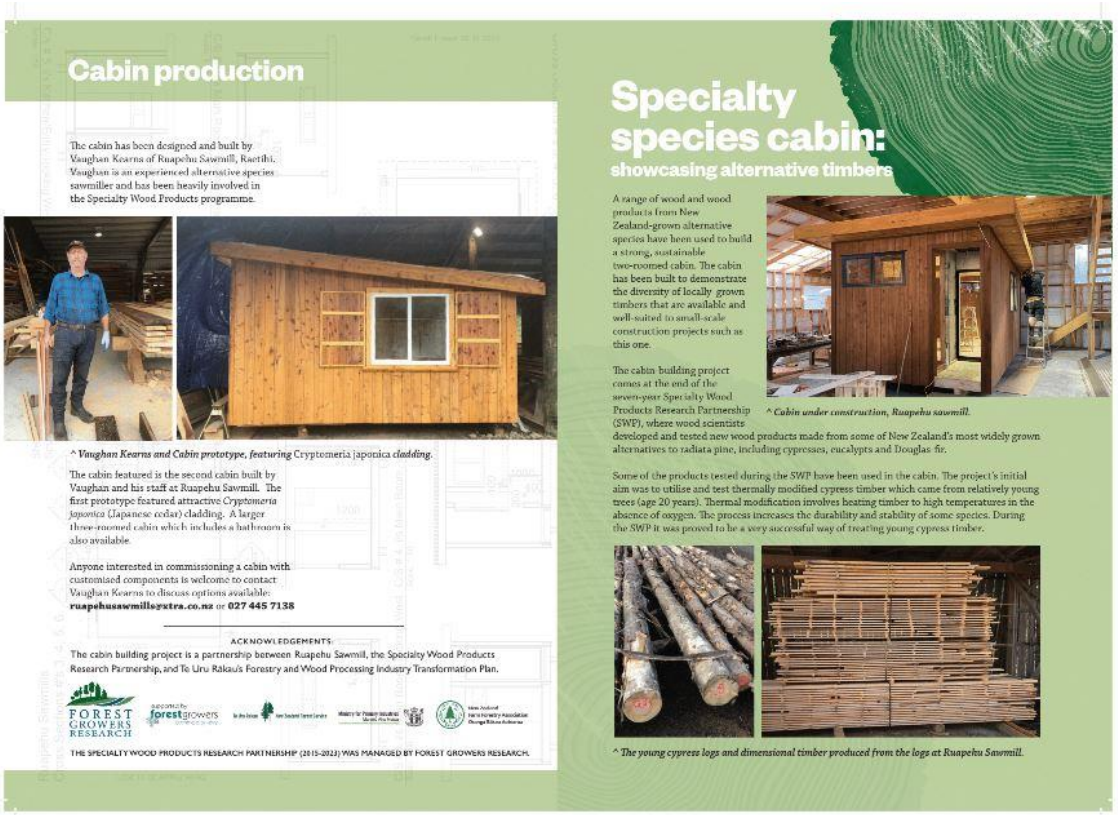
4. Import substitution – building a specialty species cabin

A range of wood and wood products from New Zealand-grown alternative species have been used to build a strong, sustainable two-roomed cabin (see Figures 12 and 13). The cabin demonstrates the diversity of locally grown timbers that are available and well-suited to small-scale construction projects. The cabin-building project comes at the end of the seven-year Specialty Wood Products Research Partnership (SWP), where wood scientists developed and tested new wood products made

from some of New Zealand's most widely grown alternatives to radiata pine, including cypresses, eucalypts and Douglas-fir. Some of the products tested during the SWP have been used in the cabin.

The project's initial aim was to utilise and test thermally modified cypress timber which came from relatively young trees (age 20 years). Thermal modification involves heating timber to high temperatures in the absence of oxygen. The process increases the durability and stability of some species. During the SWP it was proved to be a very successful way of treating young cypress timber.

Fig 6: The cabin under construction at Ruapehu Sawmills, and the interior showing the application of a range of specialty species timbers.



Cabin production

The cabin has been designed and built by Vaughan Kearns of Ruapehu Sawmill, Raetihi. Vaughan is an experienced alternative species sawmiller and has been heavily involved in the Specialty Wood Products programme.

^ *Vaughan Kearns and Cabin prototype, featuring* Cryptomeria japonica *cladding.*

The cabin featured is the second cabin built by Vaughan and his staff at Ruapehu Sawmill. The first prototype featured attractive *Cryptomeria japonica* (Japanese cedar) cladding. A larger three-roomed cabin which includes a bathroom is also available.

Anyone interested in commissioning a cabin with customised components is welcome to contact Vaughan Kearns to discuss options available: **ruapehusawmills@xtra.co.nz** or **027 445 7138**

ACKNOWLEDGEMENTS

The cabin building project is a partnership between Ruapehu Sawmill, the Specialty Wood Products Research Partnership, and Te Uru Rākau's Forestry and Wood Processing Industry Transformation Plan.

THE SPECIALTY WOOD PRODUCTS RESEARCH PARTNERSHIP (2015-2023) WAS MANAGED BY FOREST GROWERS RESEARCH.

Specialty species cabin:

showcasing alternative timbers

A range of wood and wood products from New Zealand-grown alternative species have been used to build a strong, sustainable two-roomed cabin. The cabin has been built to demonstrate the diversity of locally grown timbers that are available and well-suited to small-scale construction projects such as this one.

The cabin building project comes at the end of the seven-year Specialty Wood Products Research Partnership (SWP), where wood scientists developed and tested new wood products made from some of New Zealand's most widely grown alternatives to radiata pine, including cypresses, eucalypts and Douglas fir.

^ *Cabin under construction, Ruapehu sawmill.*

Some of the products tested during the SWP have been used in the cabin. The project's initial aim was to utilise and test thermally modified cypress timber which came from relatively young trees (age 20 years). Thermal modification involves heating timber to high temperatures in the absence of oxygen. The process increases the durability and stability of some species. During the SWP it was proved to be a very successful way of treating young cypress timber.

^ *The young cypress logs and dimensional timber produced from the logs at Ruapehu Sawmill.*

Cabin design

The cabin comprises a main room and a small kitchen. It has an internal floor footprint of 4.8m x 3.2m.

It is designed to be oriented to make the most of the sun's natural light and heat. The north side has the largest window; the east side where the kitchen is located will receive the morning sun and has a medium sized window. The west side has a small window designed to provide ventilation in hot weather, and the south wall has no windows.

The cabin is insulated to above the new H1 standards for the North Island. The windows and door are doubled-glazed aluminium.

There is a small porch which allows people to enter the cabin under shelter.

The simple kitchen contains a sink, benchtop, under cupboards and a small refrigerator/freezer. The cabin is fully wired, with four inside lights and two exterior lights, all serviced through a 32-Amp rated switchboard.

North Elevation

South Elevation

East Elevation

West Elevation

Left Front Isometric

Components

The project was born from the concept of challenging the durability of thermally modified cypress in a 'real world environment' rather than just the research environment where it had initially been tested. It has grown into the opportunity to showcase other products that emerged from the SWP, such as the engineered eucalypt flooring and eucalypt laminated veneer lumber (LVL). The cabin also displays other timbers milled and sold into New Zealand markets by Ruapehu Sawmill, one of the North Island's leading specialty timber providers.

Roof frames	Grand fir, Douglas-fir, cypress*
Roof sarking	Western red cedar
Wall frames	Cypress, *Eucalyptus fastigata* LVL
Cladding	Thermally modified poplar and cypress
Barge boards	Cypress
Ceiling linings	Poplar plywood
Wall linings	Cypress horizontal tongue and groove
Feature wall	Thermally modified cypress
Flooring	*Eucalyptus obliqua* with poplar/birch plywood backing
Support beams under cabin	Cypress

*Cypress timbers used: *Cupressus macrocarpa, C. lusitanica, Chamaecyparis x ovensii* (Ovens cypress) and *Ch. lawsoniana* (Lawson cypress).

^ *L-R: Linseed oiled interior cypress timber; thermally modified cypress feature wall; entrance porch; Thermally modified poplar cladding; engineered eucalypt flooring.*

Fig 7: Brochure produced for the specialty species cabin, which was on display at Forest Growers Research annual conference 2023 and is now on display to the public at Scion in Rotorua.

5. Durable eucalypts – adaptability and productivity

The NZDFI durable eucalypt demonstration trials planted in 2011-2014 and 2018 have provided informative data about the growth performance and site adaptability of eleven eucalypt species across a broad range of site types. They have also enabled comparisons of different sources of genetic material and demonstrated the exciting potential to achieve gains through genetic improvement.

Overall, the growth measurements show that significant improvements in mean top height/mean annual increment have been achieved through selection and site-species matching compared to the 2011-2014 trials. *Eucalyptus globoidea* has performed consistently well across a range of sites, with some exceptionally high growth rates on more temperate sites. In addition, selected *E. bosistoana, E. macrorhyncha* and *E. quadrangulata* are all exhibiting significantly improved growth rates in the 2018 trials compared with the 2011-2014 series. The survival assessments confirm the importance of site/species matching for good early survival, especially the need to avoid frost-prone sites for some species.

6. Maintaining and expanding the alternative species permanent sample plot network

There are nearly 700 permanent sample plots for alternative and contingency species around New Zealand, of which nearly 500 had not been measured in the last 10 years. The number of species on the database is 151. Of these species, 83 have less than 10 plots. The age range across all species is from age 4 through to one plot that has an estimated planting date of 1808. There are close to 100 plots that have a planting date in the 1800s - these are all native species, and planting dates could be estimated. The percent of exotic PSPs vs radiata is roughly 30/70 (exotics include other *Pinus* species such as *Pinus contorta, P. ponderosa* etc).

A re-measurement programme, combined with establishing new plots where gaps were evident was continued in this project so that in the future, the relevant growth models and yield tables can be brought up to date. Scion will record and maintain the data. Table 1 below shows what has been achieved this year, with a total of 256 plots either established or re-measured across 21 species/hybrids/clones (table 2).

Table 1: Summary of the PSP re-measurement and new plot establishment project.

Species	Existing plots measured	New plots established	Total plots	Species
Cypress	32	35	67	6
Eucalypt	83	8	91	6
Poplar	25	4	29	3
Redwood	26	33	59	1
Acacia	3	1	4	1
Western red cedar		1	1	1
Japanese cedar		2	2	1
Kauri	2		2	1
Totara		1	1	1
Total	**171**	**85**	**256**	**21**

Table 2: The 21 species included in the permanent sample plot project.

Species	
Acacia melanoxylon	Tasmanian blackwood
Agathis australis	Kauri
Cupressus ferndown	Cypress hybrid
Cupressus lusitanica	Mexican cypress
Cupressus macrocarpa	'macrocarpa'
Cupressus ovensii	Cypress hybrid
Cupressus satchelli	Cypress hybrid
Cupressus superl	Cypress hybrid
Cryptomeria japonica	Japanese cedar ('Sugi')
Eucalyptus bosistoana	Coast grey box
Eucalyptus fastigata	Brown barrel
Eucalyptus globoidea	White stringybark
Eucalyptus macrorhyncha	Red stringybark
Eucalyptus quadrangulata	White-topped box
Eucalyptus youmanii	Youmans stringybark
Podocarpus totara	Totara
Poplar var. androscoggi	Poplar hybrid
Poplar var kawa	Poplar hybrid
Poplar var. veronese	Poplar hybrid
Sequoia sempervirens	Coastal redwood
Thuja plicata	Western red cedar

Discussion: review of the overall achievements of the Diversified Forestry Project

This Diversified Forestry Project has enabled a range of projects focusing on alternative exotic species – these are the species needed to be grown, processed and marketed if New Zealand's forest industry is to diversify away from the current radiata pine near-monoculture. The project's outputs provide preliminary data and information ahead of a potential larger, long-term programme to grow confidence and de-risk investment in diversified species.

The project ran from mid-March to the end of November 2023. During this period, project proposals were submitted and approved or rejected, field work planned and carried out, lab work completed, and reports drafted. With the exception of one seed-collecting project, which will be completed early in 2024 once seed is ready, all projects have been completed within the timeframe.

A total of 15 sub-projects were funded under three workstreams:

i. **Barriers to entry**: seven projects, total value including in-kind of $637,573
ii. **Seed collection/germplasm archiving**: three projects, total value including in-kind of $135,930
iii. **Inventory and adding value**: five projects, total value including in-kind of $490,397.

Project strengths

In all three workstreams, some significant outputs have been achieved, and although the various sub-projects were not linked by any over-arching plan, they have filled important knowledge gaps is some cases and maintained progress and momentum in areas where research had already begun in others. Gains have been made in all three workstreams as follows:

i. **Barriers to entry projects** progressed initiatives in growing, processing and evaluating timber properties of durable eucalypts, cypresses, poplar and redwood – the four species which together comprise the most promising alternatives to radiata pine. The more information we have about these species, the lower the barriers to entry will be for growers, who need to be confident in their species choice. Evaluating the potential for New Zealand bio-products industries was another significant output from this workstream.

    - The value of bioeconomy in New Zealand was estimated at $12-$19 billion. This demonstrates huge potential for further product streams from forests.
    - Durable eucalypt plus-trees were selected to further advance breeding work, meaning better tree stocks for growers in future.
    - Pest and disease risks in durable eucalypts are now better understood. This reduces the chances of plantation losses and increases grower confidence.
    - Poplar plantings in NZ were documented, and the NZFFA Poplar Action Group formed to increase momentum in poplar breeding, growing and utilisation.
    - Durability data has been added to the alternative species database. Durability classes are needed to determine what applications timber can be used for, so this new information will assist in encouraging the use of alternative species in building projects.
    - Thirty-eight coastal redwood (*Sequoia sempervirens)* trees identified across 11 sites will be targeted for collection of mature budwood to contribute to a clonal archive

and seed orchard. These superior trees will be included in future breeding programmes.
- An 8-year-old cypress hybrid clonal trial was thinned, and sample logs delivered to Ruapehu Sawmills, where they have been sawn into 100 x25 mm boards and placed in fillet to be seasoned for strength testing.

ii. **Seed collecting/germplasm archiving** – work has increased the capacity to respond to growing demand for some alternative species from growers, including redwoods and durable eucalypts in particular, and increased the likelihood that planting stock with above average genetics will be available.

- Seed from a diverse range of exotic alternative species was collected and will be stored at Proseed NZ to provide security and capacity for future demand.
- Twelve kilogrammes of durable eucalypt seed was collected. This could produce over 800,000 first-grade plantable seedlings.
- 12.2 kilograms of coastal redwood seed was collected. This could produce over 85,000 first-grade plantable seedlings.

iii. **Inventory and adding value projects** included an import substitution study, which reviews New Zealand's timber importing sector, highlights the factors driving imports over the use of domestic products, and makes recommendations for the domestic sector. The specialty species cabin is an impressive demonstration of the potential to use alternative timbers in small-scale building projects. Inventory work included expanding the permanent sample plot network, using new technology to map alternative species, and assessing both cypress and durable eucalypt trials.

- Key factors driving timber imports and barriers to using New Zealand-grown timber supplies at scale were identified and can begin to be addressed.
- A remote sensing approach was further developed to classify alternative species. It estimated substantially more hectares of eucalypts, Douglas-fir, and cypress in the Wairarapa than indicated by the National Exotic Forest Description.
- Top-performing cypress clones were identified and will be used as a source of material for establishing stoolbeds for bulking up for deployment and further trials. This will allow the top clones to be made available to growers.
- A range of wood and wood products from New Zealand-grown alternative species were used to build a strong, sustainable two-roomed demonstration cabin.
- Durable eucalypt growth measurements show that selection and site-species matching have resulted in significant relative growth increases. This demonstrates the benefits of NZDFI's breeding programme and increases confidence in site/species matching.
- Remeasuring 171 existing permanent sample plots (PSPs) in alternative species and establishing 85 new PSPs will provide valuable data for current and future growth models, health assessments and species and hybrid comparisons.

Project weaknesses

- Proposals were originally scoped for a full 12 months' work and in fact this had to be compressed into nine months. This meant timeframes to start and complete work were very tight.
- FGR had to undertake to under-write some of the projects to start prior to the ITP contract being signed – this meant time-critical ones could get underway. However, some of the projects were quite rushed, with people involved coming under undesirable pressure.
- There was no overall strategic approach: this was more a series of *ad hoc* projects that were not necessarily linked.

Next Steps

Currently FGR and MPI's Sustainable Food and Fibre Futures team are undertaking a broad consultation process to understand the research and development priorities to enable the forest industry to move towards transforming into an industry which is more diverse. This will then progress to a business case and potentially lead to a large, multi-year programme of work that will include specialty/alternative species.

Overall, the Diversified Forestry Project has proved very effective in achieving a lot in a short timeframe. The challenge now is to ensure findings are communicated to wider stakeholders and are built upon in any future diverse species research and development programmes.

Appendix 1 has two tables listing all the outputs (both Technical Reports and Filenotes) from the 15 projects. All these outputs will be publicly available on the FGR website.

Appendix 2 is a table of the financials from the 15 projects. Project managers have confirmed all other cash and in-kind commitments have been meet. The ITP commitment was 50% of the total project investment. There was about 28% of the funding from the Forest Growers Levy Trust and the remainder from other cash (approximately 8%) and in-kind (approximately 14%) contributions.

As mentioned under Workstream 2 above, the only project that has not been completed is the 'Eucalypt seed collection for improved genetics'. This was solely funded by the Small to Medium Enterprise Committee and will be completed in the coming summer.

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Appendix 1: Project outputs – Technical Reports and File Notes

ITP Technical Reports

Report No.	Date	Document Title	Author(s)
ITP-TR001	Jun-23	Expansion of the Redwood Seed Collection Programme	R.H.Webster
ITP-TR002	Jun-23	What is the potential value of bio products from forests in New Zealand?	KPMG
ITP-TR003	Mar-23	Poplar cultivation: a comparison of international and national activity: Part 1	Ian McIvor
ITP-TR004	May-23	Poplar cultivation: a comparison of international and national activity: Part 2	Allan Frazer and Ian McIvor
ITP-TR005	Apr-23	Cabin CAD drawings	Vaughan Kearns
ITP-TR006	Aug-23	Import Substitution Project - Interim report	Karen Bayne; Jonathan Harrington; Colleen Chittenden; Russell McKinley; Rosie Sargent
ITP-TR007	Aug-23	Pests and Diseases of *Eucalyptus macrorhyncha*	Stephen Pawson
ITP-TR008	Aug-23	Evaluation of *E. macrorhyncha* and class 1 durable red timber eucalypts for NZ environments - workshop notes	Paul Millen
ITP-TR009	Aug-23	NZDFI seed collection from elite trees for breeding programme	Paul Millen
ITP-TR010	Aug-23	Specialty Species Cabin - show casing alternative timbers	Vaughan Kearns, Harriet Palmer
ITP-TR011	Oct-23	Decay rate of Cypress stakes after two years six months exposure at the Whakarewarewa test site	Jackie van der Waals, Ian Simpson, and Tripti Singh
ITP-TR012	Oct-23	The decay resistance of six Eucalyptus species seven years four months exposure	Jackie van der Waals, Ian Simpson, and Tripti Singh
ITP-TR013	Oct-23	A comparison of the performance of six eucalypt species planted in 2018 NZDFI demonstration trials.	Ruth McConnochie, Paul Millen and Harriet Palmer
ITP-TR014	Nov-23	Import Substitution Project - Final report	Karen Bayne; Jonathan Harrington; Colleen Chittenden; Russell McKinley; Rosie Sargent
ITP-TR015	Nov-23	Alternative species mapping for the Wairarapa Region	Vega Xu and Harriet Palmer
ITP-TR016	Nov-23	Identifying Coast Redwood 'Plus' Trees That Display Superior Heartwood Durability	R.H.Webster
ITP-TR017	Nov-23	Evaluation of Eucalyptus macrorhyncha and class 1 durable red timber eucalypts for New Zealand environments	Ruth McConnochie, Paul Millen and Harriet Palmer
ITP-TR018	Nov-23	Assessment of Eucalyptus macrorhyncha wood properties from the NZDFI Waikakaho seedling seed stand	Vikash Ghildiyal and Clemens Altaner

ITP Filenotes

Report No.	Date	Document Title	Author(s)
ITP-FN001	Apr-23	*E. macrorhyncha* and class 1 red timbered species project – stage 1	R. McConnochie and P. Millen
ITP-FN002	Aug-23	Stage 2 workplan for durable eucalypt R&D	P Millen
ITP-FN003	Nov-23	Assessment of Tarawera site 2017 Cypress Hybrid trial	Toby Stovold, Kane Fleet, Vaughan Kearns
ITP-FN004	Nov-23	Thinning and sample collection in Cypress clonal trial on the Paparoa Rd site	Vaughan Kearns
ITP-FN005	Nov-23	Abies grandis nursery research report	Vaughan Kearns

These outputs will be freely available via the FGR website (https://fgr.nz/).

Appendix 2: Project financial summary

Workstream/Project title	Key contact	Organisation	ITP $	LEVY $	Other cash $	In-kind $	Total $
WS1: Barriers to entry							
Identifying Coast redwood "Plus" trees	Rob Webster	SAG, NZFFA, KL	$92,203	$26,298		$30,190	$148,690
Evaluation of elite cypress clones	Vaughan Kearns	CDG, NZFFA, RSL	$66,500	$50,400		$20,000	$136,900
Economic Evaluation of the Bio-Forest Products Economy	Brian McMath	NZPA	$19,950	$10,050			$30,000
Assessment of Specialty Wood Products durability trials	Tripti Singh	Scion	$42,960	$21,440			$64,400
Research for growing, managing, harvesting and marketing poplar	Ian McIvor	Plant and Food	$26,600	$13,400		$10,000	$50,000
Potential for Abies grandis and other Abies species	Vaughan Kearns	CDG, NZFFA, RSL	$29,925	$15,075		$15,000	$60,000
E. macrorhyncha and assessment of class 1 durable eucalypts	Paul Millen	NZDFI, Proseed	$75,616	$36,067	$21,000	$13,900	$146,583
Subtotal			**$353,754**	**$172,730**	**$21,000**	**$89,090**	**$636,573**
WS2. Seed and germplasm collection and seed banking							
NZDFI Seed collection and banking/archiving	Paul Millen	NZDFI, Proseed	$31,933	$15,967	$9,000	$12,650	$69,550
Eucalypt seed collection for improved genetics	Vaughan Kearns	EAG, NZFFA, RSL			$20,000		$20,000
Expansion of Redwood Seed Collection Programme	Rob Webster	SAG, NZFFA, KL			$39,940	$6,440	$46,380
Subtotal			**$31,933**	**$15,967**	**$68,940**	**$19,090**	**$135,930**
WS3. Existing resource: inventory and adding value							
Assess canker-resistant cypress hybrids	Vaughan Kearns	CDG, NZFFA, RSL	$17,955	$7,885		$13,000	$38,840
Measuring the Permanent Sample Plots	Vaughan Kearns	CDG, NZFFA, RSL	$142,539	$102,591		$25,000	$270,130
Import substitution study - Scion	Andrea Stocchero	Scion	$55,000	$35,000		$22,518	$112,518
Import substitution study - Cypress cabin	Vaughan Kearns	CDG, NZFFA, RSL	$21,784	$1,125	$10,000	$10,000	$42,909
Alternative species mapping for the Wairarapa	Harriet Palmer	NZFFA	$10,000	$6,000		$10,800	$26,800
Subtotal			**$247,278**	**$152,601**	**$10,000**	**$81,318**	**$491,197**
Overheads for the project	Marco Lausberg	FGR	$17,035	$19,264			$36,299
Total			**$650,000**	**$360,562**	**$99,940**	**$189,498**	**$1,300,000**
			50.0%	27.7%	7.7%	14.6%	

Abbreviations:
CDG = Cypress Development Group
NZFFA = NZ Farm Forestry Association
NZDFI = NZ Dryland Forest Innovation
SAG = Sequoia Action Group
NZPA = NZ Product Accelerator
RSL = Ruapehu Sawmills
KL = Kingheim Ltd
Proseed = Proseed NZ