Durable eucalypt forests – a multi-regional opportunity for investment in New Zealand drylands

Paul Millen, Shaf van Ballekom, Clemens Altaner, Luis Apiolaza, Euan Mason, Ruth McConnochie, Justin Morgenroth and Tara Murray

Abstract

We believe our vision for the establishment of a durable eucalypt plantation estate is a unique opportunity to add value to New Zealand's current forest industry. With our elite breeding populations and branding strategy we have 'first mover' advantage to make this a reality by forest growers planting relatively low-value, marginal pastoral dryland to produce high-value timber. Our aim is that New Zealand will compete on innovation and excellence, rather than price, with our strategy underpinned by the increasing scarcity of tropical hardwoods and environmental constraints limiting their ongoing supply.

Introduction

The New Zealand Dryland Forests Initiative (NZDFI) was established in 2008 as a collaborative tree breeding and forestry research project. The NZDFI's aim is to select and improve drought-tolerant eucalypts that produce high-quality naturally ground-durable hardwood. The NZDFI vision is for New Zealand to be a world leader in breeding ground-durable eucalypts, and to be home to a valuable sustainable hardwood industry based on 100,000 ha of eucalypt forests by 2050.

Markets for naturally ground-durable wood exist in New Zealand's agricultural, transport and energy

E. quadrangulata, Wairarapa, age four years

A well-established NZDFI trial in Marlborough

sectors. There is also potential for high-value specialty wood products for export to international markets (Millen, 2009).

NZDFI's unique research focus and strategic vision will benefit future generations of New Zealanders by delivering the plants and knowledge to forest growers, enabling them to select and grow eucalypt species suited to their site.

NZDFI is providing landowners with a new option (i.e. to grow eucalypts that will produce a high-quality durable timber that meets the requirements of domestic and international markets), and in doing so diversify farm income. NZDFI eucalypts will also enhance environmental sustainability by combating soil erosion thanks to the tree's extensive root systems and the eucalypt's propensity to coppice (regrow from a cut stump) following felling. The new hardwood forests envisaged will offer other benefits beyond wood production (e.g. carbon sequestration, and nectar, pollen and habitat for bees and other fauna). NZDFI species also have a low wilding risk.

NZDFI pursues a strategy that involves carefully matching species to site and to end-products. The focus is on geographic regions with less than 1000 mm/yr average rainfall, especially regions where new land-use options are needed to diversify economic development. Therefore, rather than looking for generic species, we are looking for species that complement New Zealand's main plantation species and have the potential to produce high-value products. Regional development and employment could be generated through local processing to produce high-value export products that are a sustainable alternative to unsustainably logged tropical hardwoods.

Over $3 million has been invested into the NZDFI's work to date. A network of trials has been established, a long-term breeding programme will produce the first genetically-improved seedlings by 2020, and strong partnerships with research providers, landowners and industry have been developed.

However, we need to assist New Zealand forest growers develop confidence in these new species, and to learn how to successfully establish them if we are to achieve our planting of 100,000 ha as the basis for a future sustainable hardwood industry.

Durable hardwood markets

Domestic demand for sustainably-produced naturally-durable hardwood

NZDFI's inception came as a result of the huge potential market in Marlborough for vineyard posts. The wine industry's standard posts made of CCA-treated radiata pine cause a number of problems. New Zealand's grape growers break many thousands of posts annually during harvesting. These broken posts are a hazardous waste and require disposal to a secure landfill, which is expensive. The associated costs will be eliminated by using naturally-durable posts.

This brought the identification of species which could produce timber 'fit for purpose' as vineyard posts into focus. Natural durability and strength are the two essential wood properties that made durable eucalypts an obvious choice as these timbers need no preservative treatment. They are accepted by organic producers and avoid the environmental problems associated with CCA-treated timber, including the disposal problems and soil contamination.

In addition, it soon became apparent that there were other potential market opportunities, both within New Zealand and internationally. The domestic market demand for imported durable hardwood includes that required for:

- Critical infrastructure products such as cross-arms for power poles, rail sleepers, posts and poles that underpin this country's electricity and rail networks
- Posts and poles not only for vineyards but also for kiwifruit, hops and other horticultural crops needing trellis structures.

New Zealand also requires imported hardwoods for specialty decking, flooring and joinery use. By establishing forests of elite eucalypt species, New Zealand can become a leading sustainable producer of naturally-durable hardwood for these uses. This hardwood will be processed in the regions where it is grown and supplied as high-value products for domestic and export sales.

International demand for high-value naturally-durable hardwood

Coloured heartwood associated with tropical species, such as teak and rosewood, are highly sought after by international markets. Much of this demand is currently supplied from illegal/unsustainable sources. For example, the current rosewood demand is apparently worth more than the trade in ivory, pangolins, rhino horn, lions and tigers put together (e.g. see www.unodc.org/unodc/en/data-and-analysis/wildlife.html and www.bbc.co.uk/programmes/p05hll9v).

There are international efforts to combat illegal timber trade and consumers are demanding sustainable supply, with Australia, EU countries and the US all having laws that require wood imports to be from legal sources. As some durable eucalypt species are renowned for their rich, dark timber these can substitute tropical hardwoods and be given a strong sustainability brand if grown in New Zealand durable eucalypt forests managed under sustainable principles.

The opportunity in China alone is large, with annual imports of up to 15 million m^3 of hardwood logs, and 10 million m^3 of hardwood sawn timber, worth over US$8.4 billion (FAO, 2016).

In Australia, indigenous durable eucalypt forests have been producing highly-prized hardwoods, such as ironbark and jarrah, for domestic and export sales since the early 1800s and throughout much of last century. However, conservation needs and logging restrictions

Pruning four-year-old *E. bosistoana* at a Marlborough trial site

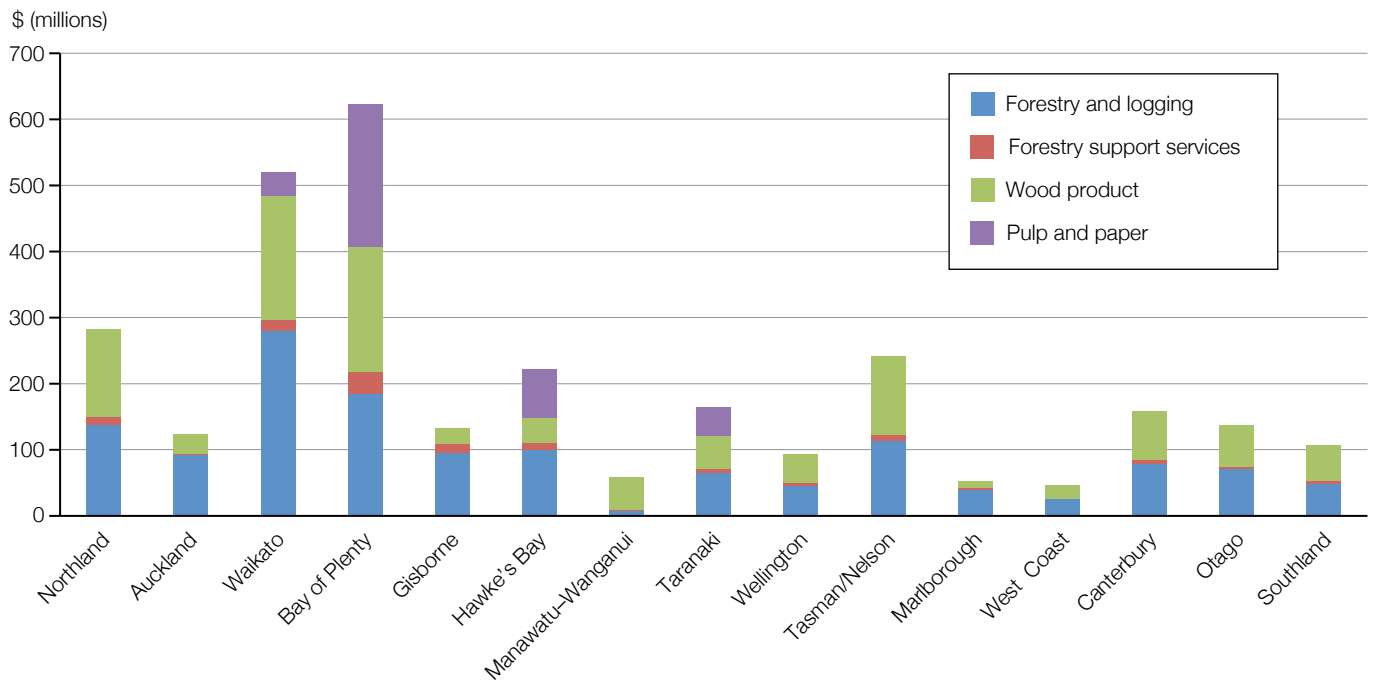

Figure 1: Contribution of forestry to regional GDP. Source: NZIER

have created significant supply gaps, as plantation eucalypts in Australia are almost universally grown for pulp wood rather than high-value timber uses, with what is left of the traditional native timber cut principally for sale to valuable domestic markets.

While there have been some durable eucalypt plantations established in Australia (e.g. see heartwoodplantations.com.au/), these are insufficient in scale to substitute the huge log supply formally cut from the indigenous eucalypt forests. The most recent report by Australian Forest and Wood Products Statistics indicates that Australia is importing more than $5 billion in wood products annually to meet the demand unable to be supplied locally.

New Zealand's Annual Forestry Statistics produced by the Ministry for Primary Industries (MPI) reported for the year ended 30 June 2017 that total hardwood timber imports were over 40,000 m^3 and worth almost $50 million, with $1,200/$m^3$ therefore the average unit value of the sawn timber imported. This includes South East Asian kwila, North American white oak, South American purpleheart, Tasmanian oak and many others (full statistics can be found at https://catalogue.data.govt.nz/dataset?tags=forestry).

An average unit value of $1,200/$m^3$ for imported sawn hardwood timber is two-and-a-half times greater than the average unit value of New Zealand's radiata pine sawn timber exports. While total pine exports were worth over $800 million to the end of June 2017, the average unit export value is only $472/$m^3$.

Market demand for high-strength engineered wood products

In addition to hardwood posts, poles and sawn timber, there is significant export potential for both naturally-durable solid wood products and high-strength laminated veneer lumber (LVL), which is also increasingly being demanded in international timber construction markets.

Production and export of 61,000 m^3 of radiata pine-based LVL and plywood is currently delivering the highest export unit value for forest products processed in New Zealand. To the end of June 2017, annual exports were worth over $127 million, with an average unit value of over $2,000/$m^3$.

LVL producers in New Zealand are looking for an alternative fibre supply to radiata pine as the size of timber buildings is increasing dramatically and large wooden construction places high demands on the stiffness of the utilised timber products. There is a market premium of 30% for super-stiff timber products (16 GPa and above), but these cannot be manufactured from radiata pine as it does not produce wood of high stiffness. 13GPa pine LVL is the maximum manufactured commercially in New Zealand.

On optimal sites, eucalypts can achieve growth rates that exceed those of radiata pine while producing much stiffer wood. Therefore, eucalypts could be well suited to supply wood for structural timber products such as LVL or plywood, achieving three different objectives:

- Production of higher-value structural products (16 GPa and above) that require exceptionally stiff veneers could be obtained from some durable eucalypts in reasonable quantities
- For standard LVL products (8-13 GPa), which are currently manufactured from radiata pine, fibre costs could be reduced by utilising trees grown in shorter rotations and achieving higher-veneer yields
- Manufacture of a high stiffness hybrid eucalypt and radiata pine LVL will produce a greater total volume

of product for export, thereby adding value to New Zealand's pine resource.

Other potential forest sector benefits offered by durable eucalypts

Diversify the forestry sector by introducing an alternative to radiata pine for East Coast regions

NZDFI's unique research focus has identified not only that the East Coast's soils and climate have the potential to diversify forestry by supporting durable eucalypt forests, but also that our selected species can survive and thrive in demanding summer-dry conditions.

Marlborough/Nelson and the North Island East Coast regions from Gisborne to Wairarapa already have a successful radiata pine forestry sector that makes a major contribution to regional GDP. This is shown in the NZ Institute of Economic Research (NZIER) 2017 report on 'Plantation Forestry Statistics' (see Figure 1).

The forest industry in these regions already supports many jobs, both in managing the 537,000 ha of plantations, and in harvesting, with an estimated 3.1 million m^3 harvested in 2017. These regions are also well serviced with timber processors and export ports.

Like the rest of New Zealand, forest growers in these East Coast regions rely almost totally on a single species, radiata pine, leaving the industry vulnerable to climate change, fluctuations in market demand and the threat of pests and diseases. Climate change will bring hotter and drier conditions in the east of the country, with more frequent and more severe droughts (e.g. see www.niwa.co.nz/our-science/climate/information-and-resources/clivar/scenarios#regional).

NZDFI are promoting the rapid expansion of a sustained planting programme in the East Coast regions to establish a resource that can produce sufficient future log supply to sustain a new hardwood industry. Their vision is for a mosaic of forests rather than only large-scale plantations, as there could be a durable eucalypt woodlot planted on every dry hill country farm in these regions.

Reduce use of CCA-treated pine in New Zealand's agricultural, horticulture and viticulture industries, and urban environments

There are large volumes of CCA-treated timber used in New Zealand's diverse agricultural industries (e.g. vineyards and kiwifruit orchards), as well as in urban environments. This use is projected to continue and increase as a result of land-use intensification. This is despite increasing international consumer resistance to CCA-treated timber, with use restricted or banned in many countries. There are market advantages and significant environmental gains if this country can reduce the production of CCA-treated products, and thereby reduce hazardous wood waste going to landfills or being illegally dumped or burnt.

Environmental benefits of carbon sequestration, honey production and erosion control

New eucalypt forests could sequester greater amounts of carbon than pine due to their rapid early growth and higher wood density. They can be planted for inclusion in New Zealand's Emissions Trading Scheme.

There is significant pressure on New Zealand's apiary industry, including the need for bee forage to support hives. Durable eucalypts flower prolifically producing high-quality nectar and pollen able to support bees, and hence can contribute to hive health and honey production. Some durable eucalypts flower outside the mānuka flowering season, and so plantations could be established to complement mānuka honey enterprises. Many types of eucalyptus honey are sought after in Australia so extensive plantations in New Zealand's East Coast will present the opportunity for an additional honey crop.

New Zealand's East Coast faces increasingly frequent and severe droughts, and more high-intensity storms, due to climate change. Planting durable eucalypts could enhance long-term environmental sustainability by combating soil erosion: durable eucalypts have extensive root systems with some species able to grow on skeletal soils and to rapidly recycle soil organic matter. They also coppice (re-sprout) following felling, thereby minimising the post-harvest time-period without canopy cover, a predisposing condition for erosion.

Past eucalypt research initiatives

The early experiences with growing eucalypts for solid wood products in New Zealand are summarised by Barr (1996). Two New Zealand eucalypt research initiatives in the early part of the 21st century are worth mentioning. Both of these projects were undertaken with scarce resources, and although done as well as possible given the resource constraints, they are ultimately not suitable as the foundation for a serious breeding programme.

FRI/Scion stringybark trials

A good start was made by Scion (NZ Forest Research Institute Ltd, FRI) to investigate the stringybark eucalypt group for solid wood uses (Shelbourne et al., 2002). Proseed NZ Ltd assisted with seed collections, with seed from 12 species and 69 provenances being supplied. In 2003, Scion planted a set of research trials of 12 species from the stringybark group. This research was focused on testing a selection of durable species for survival and early growth. Unfortunately this work was curtailed due to a lack of funding.

NZFFA stringybark trials

Then in 2003–2004 the NZ Farm Forestry Association (NZFFA) established a network of eucalypt

evaluation trials, funded by the MPI's Sustainable Farming Fund. These trials were established on some 40 sites throughout New Zealand and comprised 15 tree row plots of 10–15 species per site. These sites are still occasionally monitored, but there is no ongoing formal research programme associated with them.

Lessons from Australian tree breeders

There are lessons the NZDFI can take from Australian tree breeders (Eldridge, 1993). Eldridge looked at why there are not more eucalypt plantations in New Zealand and suggested a number of reasons including (Eldridge, pers. comm. 1996):

- Insufficient continuity of funds and staff for research
- Dominance and success of radiata pine, and its ease of production across a wide range of sites, which has made eucalypts (and other species) of minor importance to the New Zealand forest industry
- The reluctance of New Zealand forest managers to recognise that eucalypts might be at least as profitable as radiata
- Site/species matching and site preparation, considered generally much more important with eucalypts than with radiata pine. Eldridge was not impressed by what he saw in New Zealand
- Pests and diseases – part of the problem is that eucalypt species planted have not been well adapted to planting sites and are therefore more vulnerable to pest and disease attacks. Eldridge considered integrated pest management as essential.

In summary, numerous eucalypt species have been tested in New Zealand for solid wood production, but until the NZDFI initiative there was never a long-term properly planned and funded tree improvement programme to enable the full potential of the genus to be explored. Proseed NZ Ltd and the NZDFI recognised the potential for further species and provenance testing, and this has driven the NZDFI programme forward since its inception in 2008.

Selection of species and seed collection

Species chosen for research effort

Species selection by NZDFI builds upon decades of research conducted by the Special Purpose Species Group of Scion; the Eucalypt Action Group of the NZFFA; and collaboration between Vineyard Timbers, the Marlborough District Council, Proseed NZ Ltd and several private landowners in Marlborough. Our five species were chosen from a shortlist of the 25 most promising species, which included nine stringybarks.

In Marlborough, between 2003 and 2006, over 80 small research trials of 25 durable eucalypt species were established in an early research joint venture between Vineyard Timbers, the Marlborough District Council, Proseed NZ Ltd and several private local landowners. When species were being selected for trial work, the following fundamental criteria were identified:

- High natural durability (Australian Standard Class 1 or 2)
- Fast growth, straight stems
- Early heartwood formation and good colour
- Drought and frost tolerant
- Pest tolerant
- Vigorous coppice
- Good nectar/pollen production for native biodiversity and bees.

Table 1 lists the species planted in the first of NZDFI's trials, all of which were located in Marlborough, the heart of New Zealand's wine industry:

Table 1: Durable eucalypt species first trialled by the NZDFI

Symphyomyrtus	Monocalypts
Eucalyptus bosistoana	*Eucalyptus agglomerata*
Eucalyptus camaldulensis	*Eucalyptus blaxandii*
Eucalyptus cladocalyx	*Eucalyptus cameronii*
Eucalyptus maidenii	*Eucalyptus eugenoides*
Eucalyptus melliodora	*Eucalyptus fastigata*
Eucalyptus microcarpa	*Eucalyptus globoidea*
Eucalyptus moluccana	*Eucalyptus laevopinea*
Eucalyptus quadrangulata	*Eucalyptus longifolia*
Eucalyptus saligna	*Eucalyptus macrorhyncha*
Eucalyptus tereticornis	*Eucalyptus microcorys*
Eucalyptus wandoo	*Eucalyptus muelleriana*
	Eucalyptus obliqua
	Eucalyptus pilularis
	Eucalyptus youmanii

From these initial trials, and other research and knowledge of existing eucalypt stands in New Zealand, three key species were selected as the focus for tree improvement work:

- *E. bosistoana*
- *E. globoidea*
- *E. quadrangulata.*

Two additional species were added to the breeding programme in 2011. A small number of selections of *E. argophloia* and *E. tricarpa* were established in progeny tests because of their potential to hybridise with *E. bosistoana*, to introduce red timber colouring and

pest tolerance. All these species are grown in the NZDFI's network of breeding trials. In addition, a further six species have been identified as being of interest:

- *E. camaldulensis*
- *E. cladocalyx*
- *E. eugenioides*
- *E. longifolia*
- *E. macrorhyncha*
- *E. notabilis*.

Seed collection

The three main species selected by the NZDFI for genetic improvement have never undergone any formal domestication. Furthermore, there is very little genetic material available in New Zealand. Therefore, individual family seedlots were purchased from seed providers in Australia where available but these were very limited. Proseed NZ Ltd contracted extensive seed collections to provide broad-based genotypes of *E. bosistoana*, *E. quadrangulata* and *E. globoidea* from across the natural range of these species.

As of 2017, NZDFI has deployed ~180 *E. bosistoana*, ~150 *E. globoidea* and ~100 *E. quadrangulata* families in multiple breeding trials, making it one of the largest breeding programmes for durable timber internationally. As additional seed becomes available it will be included into the breeding programme. *E. argophloia* and *E. tricarpa* have small breeding programmes in Australia and family seedlots were obtained from DPI Queensland and Forests NSW.

These species are planted, together with those mentioned above, in smaller demonstration trials from the Bay of Plenty to North Canterbury that are regularly monitored to obtain information on their performance on a range of different sites. Together with our breeding populations they are the foundation of the NZDFI research programme (see Figure 2).

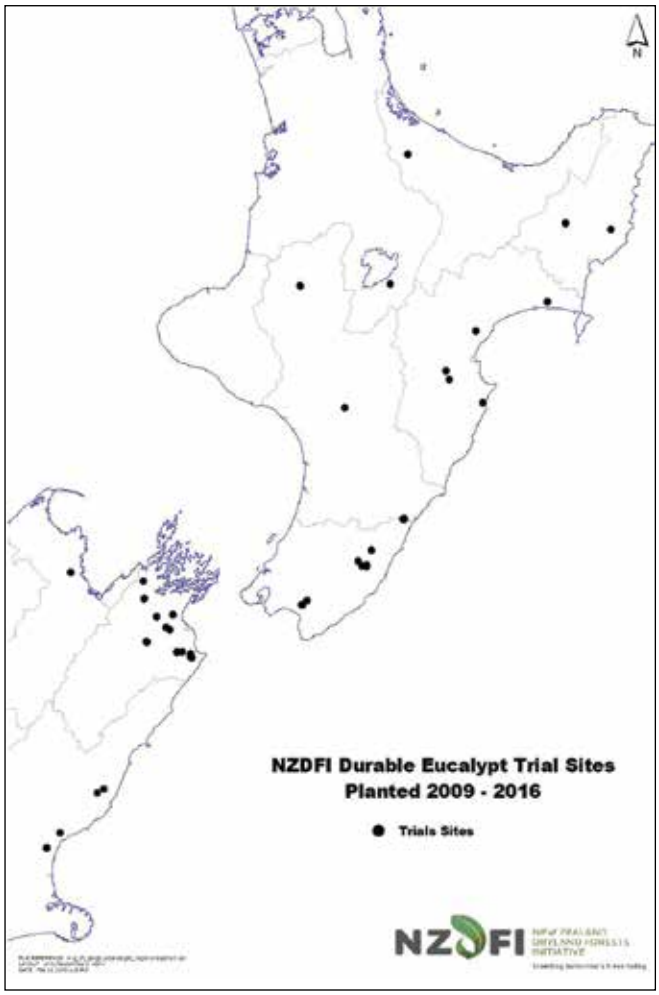

Figure 2: NZDFI trial site network

NZDFI's tree breeding and research programme

Knowledge of New Zealand's domestic demand for high-quality naturally ground-durable hardwood and the potential to export to international markets has led the NZDFI into a product-focused research programme.

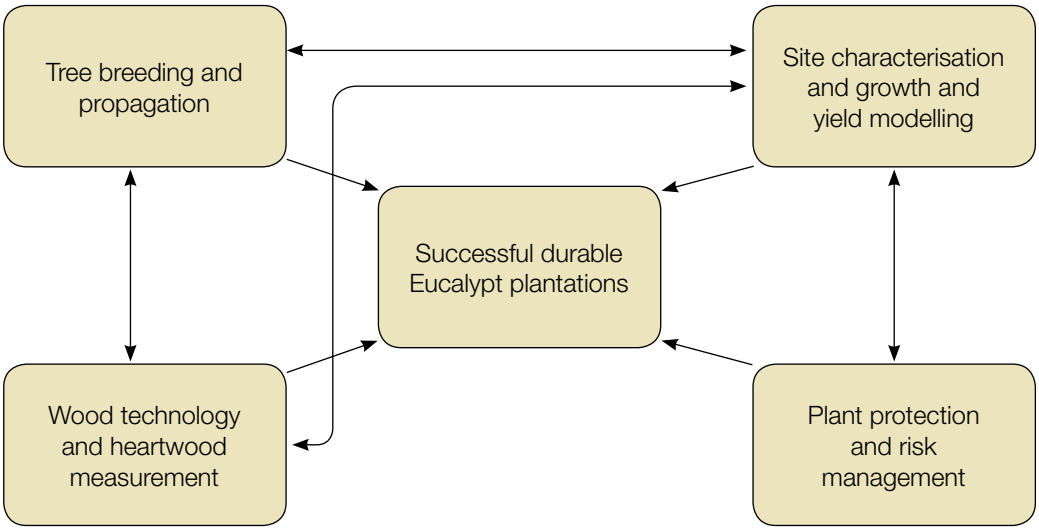

Figure 3: Linkages between NZDFI research streams designed to support growers of dryland eucalypt species

It is envisaged that growers will benefit from two income streams by harvesting at different ages:

- On flat-to-easy sites with good road access and short transport distances, roundwood thinnings or clear fell from around age 12 onwards – logs suitable for preservative-free posts and poles for vineyards, horticulture and organic enterprises, and potentially for rotary peeled veneers
- On less accessible sites, sawlog harvest at around age 25 onwards – timber for cross-arms, sleepers and poles (rail and outdoor landscaping), small wharves and marinas, including decking, furniture and interior fittings (Asia), and engineered wood products.

NZDFI also want to encourage smaller-size durable eucalypt plantations (woodlots and shelterbelts) due to the diversity of benefits these species offer if planted in farm environments. These benefits include:

- On-farm production of posts, poles and timber for farm infrastructure with no treatment required
- Excellent firewood
- Nectar and pollen production
- Shelter and shade for stock
- Some eucalypt species have been proven for remediation of waste water through the use of spray irrigation in plantations and could have the potential to strip nitrates from ground water if planted and harvested with care in riparian margins.

Durable eucalypts can live hundreds of years so could also be established as permanent forests on steep unproductive land for erosion control and to sequester carbon. The trees could be spaced widely to allow native planting or regeneration to also form the long-term forest canopy.

Requirements for New Zealand growers to be successful in growing eucalypts to produce durable hardwood can be divided into product and market information, access to well-characterised superior genotypes, help with matching species to the right sites, predictions of forest growth and yield that include information about volumes of different products that might be grown on those sites, and reduced risk of failure due to clear guidelines for the protection of crops from insects and diseases. These are distinct research streams, but they are also linked (see Figure 3.)

Vineyard stakes, Wanganui

E. bosistoana board

Several of the species that will suit growers have not been previously domesticated. Our breeding programme will identify and propagate genotypes that exhibit rapid volume growth, good form, and plenty of highly durable, low-growth-strain heartwood. This key first step has been underway for several years now. We have almost completed a full generation of improvement for *E. bosistoana*, but still have to progress with the characterisation of wood properties for our other species.

The core of the NZDFI research involves developing eucalypts of superior quality wood (i.e. durable and low-growth-strain wood). Our wood properties research involves the development and application of early and rapid assessment of long-term wood durability and growth strains for different species and genotypes. This research is closely aligned to the implementation of the NZDFI breeding programme.

Working on a range of promising species increases the likelihood of programme success, and makes the work applicable to a wider range of environments and economic circumstances. Matching the right genetic material that will thrive on difficult sites is an essential part of the programme.

Therefore, our site-species matching research programme aims to provide easy access to software that delivers high-quality descriptions of site attributes anywhere in New Zealand, along with ranked suggestions for NZDFI species that might be grown on those sites for particular purposes. In addition, growth and yield models will provide summaries of measurements from our trial sites that enable the best possible predictions of yields on those sites.

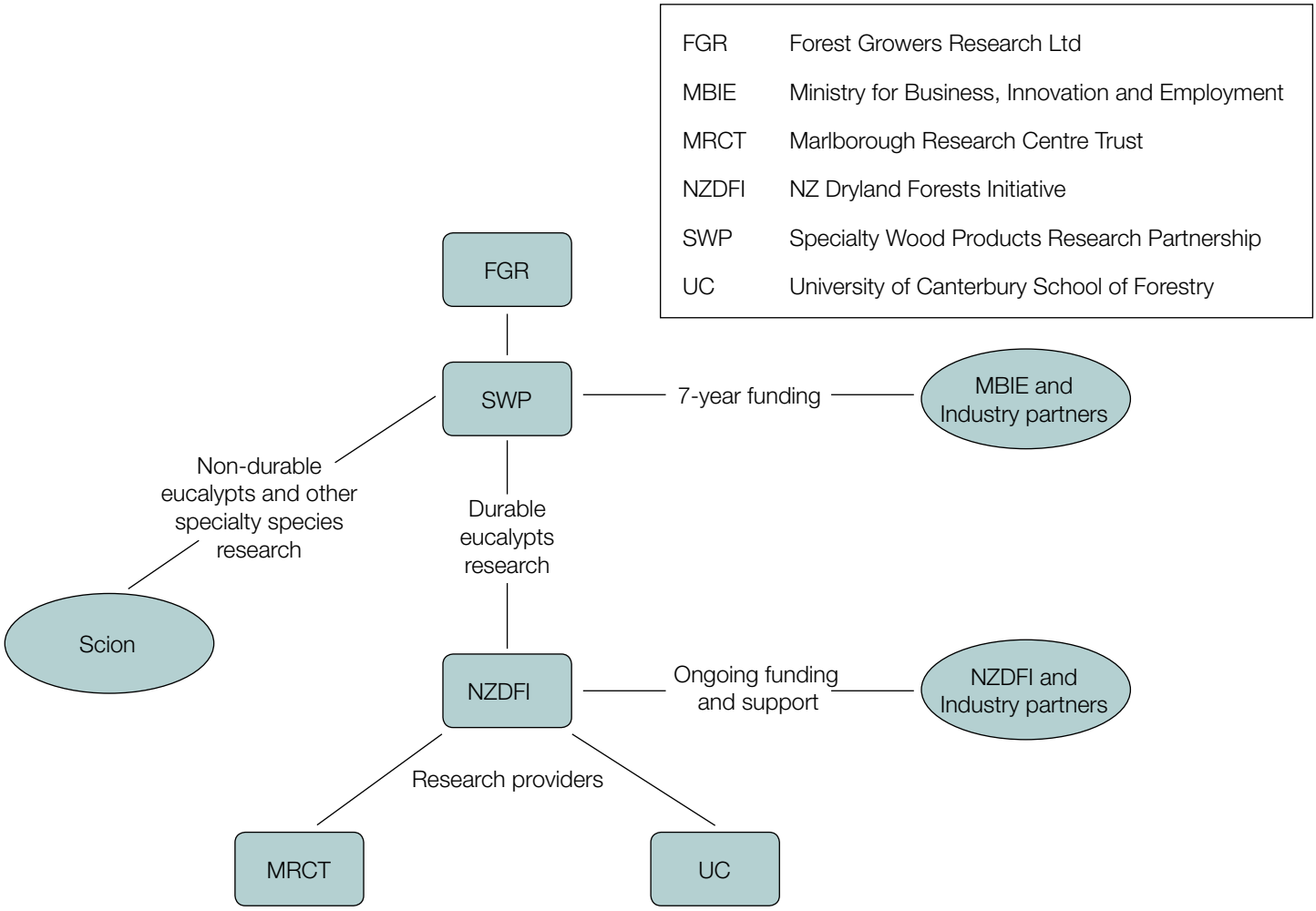

Figure 4: Relationship between NZDFI, its stakeholders and research providers

Ultimately, as our datasets become more complete these predictions will include survival estimates, stem dimensions, stem shapes, and also yields of durable heartwood. There will be a facility to identify log types as well. These estimates can be placed into discounted cashflow spreadsheets that will allow growers to compare silvicultural regimes and determine optimal rotation lengths.

Growing high-value crops with clear objectives is less risky if we understand the threats from insects and diseases and know what impacts they are likely to have on tree crops in particular conditions. Eucalypts may experience problems with pests and diseases. These problems occur all over the world, including where the most successful plantation species belong to the subgenus Symphyomyrtus: *E. globulus* (in temperate regions) and the hybrid *E. urophylla* x *E. grandis* (in tropical regions).

Pests can be specific to eucalypts or generalists and this is an evolving problem. We do know that the NZDFI species can be susceptible to defoliators. Our forest health research programme has been screening the presence of pests in breeding trials and this will be complemented with broader evaluations in the species trials. Insect load and defoliation vary with stand age and location and this work is expected to continue for several years. This research will help growers cope with threats and reduce risk.

The elements of the NZDFI research programme are inevitably linked. For instance, species and genotypes will differ in heartwood content and durability. Durability and heartwood content need to be represented in growth and yield forecasts, and these forecasts should take into account different genotypes, not just different species. Site selection and pest risk are related, and pests can impact on growth and yield.

The research programme is regularly reviewed by domestic and international experts from industry and academia, and now involves collaboration with researchers from Australia, Japan and Germany.

NZDFI – achieving success by collaboration

From 2008 to 2016, $3 million has been invested in the NZDFI research and development programme, with about $0.6 million from central government via two MPI Sustainable Farming Fund projects and $100,000 from AGMARDT. NZDFI's founding partners (see below) invested $1.8 million over this time. Another $0.5 million has come from other supporters including Marlborough Lines, the NZFFA, multiple regional

councils and forest growers from the East Coast regions (Bay of Plenty, Gisborne, Hawke's Bay, Horizons, Greater Wellington, Marlborough and Canterbury).

In July 2015, NZ Forest Growers Research Ltd, with funding from the NZ Forest Growers Levy Trust and the support of the NZFFA, established the Specialty Wood Products (SWP) research partnership with the Ministry of Business Innovation and Employment. Via this partnership both the University of Canterbury and the Marlborough Research Centre Trust (MRCT) are contracted to continue with NZDFI's durable eucalypt tree improvement programme, while Scion are contracted by NZ Forest Growers Research Ltd to continue research on non-durable eucalypts already planted in New Zealand for sawlog and pulp wood production (see Figure 4).

NZDFI partners

NZDFI's success has been built on collaboration with four main partners (Table 2), who have all been active in bringing together an integrated research programme. The MRCT established the NZDFI project in July 2008 under a Memorandum of Understanding with the NZDFI's founding partners – Proseed NZ Ltd, Vineyard Timbers Ltd and the University of Canterbury.

The partnership has benefited from having a well-defined long-term strategy, innovative contributions by all key players, and consistent management since its inception. The NZDFI Science Team is a group of University of Canterbury academic staff and numerous postgraduate students who work alongside Marlborough Research Centre consultants and the propagation research team at Proseed NZ Ltd in Amberley. Together this team plans and manages the highly-integrated research programme (see nzdfi.org.nz/research-trials/). The NZDFI's research has been successful because we work closely with the 30 landowners who host our extensive network of trials.

Table 2: NZDFI partners and areas of activity

Partner	Area of activity
Marlborough Research Centre Trust	Trial management, trial assessments and outreach programme
Proseed NZ Ltd	Seed collection, propagation, seed orchard management
NZ School of Forestry (University of Canterbury)	Manage a comprehensive research programme including: site-species matching, growth and yield modelling, tree health, breeding (growth, health, wood quality), wood processing
Vineyard Timbers Ltd	This is the company of NZDFI Project Manager, Paul Millen

NZDFI supporters and extension

There are many other stakeholders within NZDFI's wide community of interest. This includes numerous individuals, plus farm forestry and forest industry organisations/companies and local government organisations that all actively support NZDFI's research programme. Effective communication and extension to industry includes targeting the delivery of information and results from the NZDFI's research programme to the regions that offer the most opportunity.

The Marlborough Research Centre's NZDFI extension strategy is driven by the support and interest forged with: the 30 landowners who own the trial sites; the many farm foresters and forest companies that have already started planting; and other forest industry organisations and East Coast regional councils. Those who are part of NZDFI's 'community of interest' are working collaboratively to achieve NZDFI's vision.

NZDFI's research and knowledge is disseminated through: regular project updates to the NZDFI contact list; updates also posted to the NZDFI website www.nzdfi.org.nz; refereed publications and articles written for industry sector publications such as *NZ Tree Grower* and academic journals; and presentations delivered at the annual Forest Growers Research conference and other forest industry and rural sector workshops and field days.

Māori involvement and commitment to Vision Mātauranga

There are already Māori participants in NZDFI's research and development programme, these being Ngāi Tahu and Ngāti Tuwharetoa, while Te Tumu Paeroa is an investor in the wider focus of the SWP programme. Ngāi Tahu is directly involved as a founding partner of the NZDFI through their subsidiary company Proseed NZ Ltd. This company is the largest Australian producer of improved radiata seed. Their CEO, Shaf van Ballekom, is also NZDFI chairman. In 2014, Proseed NZ Ltd opened a new controlled-propagation facility to undertake propagation research followed by planting their first seed orchards of durable eucalypts in 2016.

Lake Taupō Forest Trust (Ngāti Tuwharetoa) has planted trials of durable eucalypts in order to diversify the species they grow. Their land will be in forest in perpetuity due to the nitrate issues in the Lake Taupō catchment. If successful after further trials, the Trust could scale up planting if sustainable market demand of sufficient scale is proven.

NZDFI support the Vision Mātauranga goal to unlock the potential of the Māori economy, and the Crown Māori Economic Growth Partnership, He kai kei aku ringa. Patterns of Māori forest ownership are changing. As land managed by other entities under Crown Forest Licences has reverted back to iwi, Māori forest ownership/management is approaching 40% of the total forested area. Māori are seeking options for

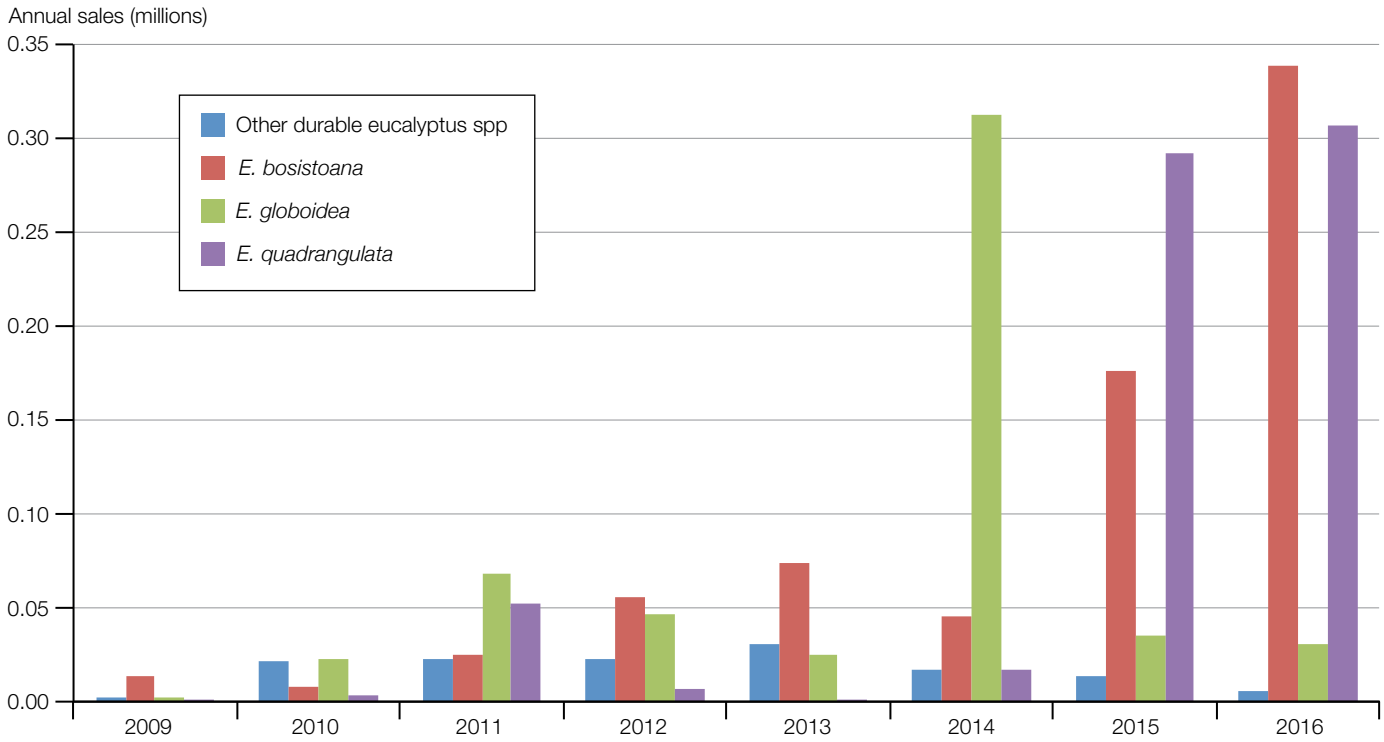

Figure 5: Annual nursery sales of durable eucalyptus seedlings by species

early cashflow and to maximise returns from their land – these benefits could be delivered by our durable eucalypt species.

However, NZDFI recognise that iwi are cautious investors – they cannot put either their land or their recent Treaty of Waitangi settlements at risk. So it is through a process of developing a regional strategic plan that NZDFI is seeking the leadership of appropriate government agencies to assist in broadening Māori engagement and to give them confidence to plant durable eucalypts on their lands.

Current status of NZDFI

Amongst the NZDFI's achievements since its inception in 2008 we have had some major milestones:

- Establishment of breeding trials: 150,000+ individual trees from five species in 23 breeding trials at 10 properties in four regions (Marlborough, Wairarapa, Hawke's Bay, Gisborne)
- Establishment of demonstration trials: 40,000 trees with up to 11 species in demonstration trials on 25 sites in seven regions
- First seed from *E. globoidea* Waikakaho seed stand available from 2014
- First selections of *E. bosistoana* and *E. globoidea* for growth and form grafted for clonal seed orchard (2014–2018), plus seedling seed orchards of other species
- Propagation facility built at Amberley (2014).

NZDFI's first regional value chain is most likely in the Hawke's Bay/Gisborne regions and in Wairarapa based on short rotation forests that will commence in 2035 to supply small peeler logs to produce super-stiff LVL. This product has already been identified by Juken NZ Ltd, an integrated forestry and processing company based in both Gisborne (sawn timber) and Masterton (sawn timber and plywood and LVL). Juken NZ Ltd hosts several NZDFI trials, has played an active role in the NZDFI since 2011, and planted several hundred hectares of durable eucalypt (with unimproved plants) over the past seven years.

There are other East Coast forest growers and farm foresters, including Landcorp Farming and the Hawke's Bay Regional Council, who have been collaborating in NZDFI research. They have already started planting durable eucalypts and plan to increase this once improved planting stock is available so as to be first to market with New Zealand grown high-strength LVL and durable hardwood products.

Therefore, a major next step from here will be to develop an economic model for forestry investment in short rotation plantations to produce log supply for high-strength LVL. This model will be developed and expanded over time to evaluate potential returns for a range of durable eucalypt plantation investment options based on a suitable analysis of the sites under consideration for planting.

Planting durable eucalypts is increasing

The interest in planting durable eucalypts is increasing with some forest growers having already planted commercial blocks so as to establish a forest

resource for processing as soon as possible. The most accurate way to gauge the uptake of durable eucalypts is to analyse nursery sales by species (see Figure 5). In 2015, the estimated total durable eucalypt seedlings sold by nurseries was over 500,000, and in 2016 over 680,000 – a significant increase from earlier years.

Branding NZDFI germplasm

NZDFI's partners have developed a strategy for branding the quality of germplasm captured within improved nursery stocks so that farm foresters and forest growers can select these plants to ensure high productivity and wood quality in their forests. To this end the XyloGene trademark has been registered with the International Property Office of New Zealand (see Figure 6).

Figure 6: The XyloGene brand

This trademark could be used for more than seed and seedlings. By planting forests with branded and certified improved nursery stocks, there is also the opportunity for future market traceability of the durable eucalypt hardwood grown in these forests. The logs could be tracked from the forest to the timber produced, and the XyloGene brand used as a certifying trademark to identify and differentiate all products including posts, poles, sawn timber and processed products such as veneers containing timber from XyloGene seedstock. Trademarks are critical to long-term international export success and NZDFI's partners are requesting New Zealand's government to consider how to develop this opportunity from the onset of a major planting programme.

Biological risks

NZDFI's partners understand there are significant biological risks that threaten the substantial capital investment that is required if 100,000 ha of durable eucalypt plantations are to be established. These include: climate and soil being unsuitable for the species chosen for any particular afforestation site; poor handling of nursery stock during establishment and incorrect timing of planting; despite genetic improvement some young eucalypt seedlings can develop poor form; and insect pests and diseases and fire.

Pests and diseases for eucalypts have come more into public view with the recent arrival of myrtle rust (*Austropuccinia psidii*) and a new defoliating beetle (*Paropsisterna varicollis*) in New Zealand. Eucalypt growers in this country have to accept that there are numerous pests and diseases, either already present in the country or at risk of arriving from overseas, which could affect their crop because of the lack of natural predators. This is not unique to eucalypts and applies to almost all agricultural crops. Pests and diseases for eucalypts need to managed, and have been successfully managed in the past (Wardlaw, 2017).

Eucalyptus variegated beetle (*P. varicollis)* is a serious potential threat to eucalypts in New Zealand (Lin et al., In press). Research on the impacts of this beetle is underway as part of the NZDFI research programme. However, the current experience does not suggest that the threat is worse than that of another eucalyptus defoliator *Paropsis charybdis* (Eucalyptus tortoise beetle) which has been in New Zealand for a century.

Myrtle rust has recently arrived from Australia. Experience from Australia with this disease suggests that it can be successfully managed. It is restricted to certain climatic conditions and it has been shown that more resistant genotypes within eucalyptus families exist (Potts et al., 2016).

The implications of these diseases are not yet known, but NZDFI partners will be keeping a close eye on their reported spread. Work to establish an integrated pest management programme has begun, as has the search for more pest-tolerant genotypes (Murray & Lin, 2017).

Some of the other risks can be mitigated through:

- Careful site planning by farm foresters and forest growers so as to correctly match species to site
- Completing establishment operations to a high standard which does require different methods to those used for planting pine
- Form pruning (to create a single straight stem) may be necessary to ensure optimal selection of crop trees
- Locating plantations and woodlots of durable eucalypts in sites with low fire risk and not establishing plantations in peri-urban areas.

A further public and landowner concern may be that durable eucalypts pose a threat of producing wildings (i.e. they will spread beyond plantation boundaries) and become an environmental nuisance. Despite many eucalypt species having been introduced into New Zealand and planted across a wide range of environments, they are not known to have developed wildings. This could be due to the specificity of sites that eucalypts require, as well as the care required for establishment. Also eucalypt seed does not naturally disperse over long distances, so we consider the risk of eucalypt wildings is low.

Recent developments in the forestry sector

On a final note, the New Zealand elections in October 2017 delivered a Labour/NZ First/Green government that has already announced it will set up a new Forestry Service as a part of its regional development plans. This new organisation will be tasked with planting one billion trees over 10 years with a target of planting 100 million trees annually at 1000/ha; this equates to 100,000 ha annually.

Each year about 50 million trees are already planted in New Zealand, with many used to re-plant cut-over (recently harvested) pine forest. The new government's planting target aims to double this. This commitment to directly invest in planting new forests is one of the government's regional development goals, and will create jobs in the regions with roles in forest establishment, management and nursery stock production.

NZDFI's first major milestone on the path to achieving our vision to 2030 and beyond will be to commence commercial release of improved planting stock by 2020. Therefore, given this recent announcement, NZDFI's partners are engaged with the new government to seek feedback on their vision for the planting of 100,000 ha of forests to produce durable eucalypt timber in the dryland East Coast regions.

More specifically, NZDFI wants to engage both central and regional government, together with those in New Zealand's forestry and agricultural sectors, in developing a multi-regional strategic plan to provide direction on empowering landowners to successfully plant new durable eucalypt forests.

While $3 million has already been invested in NZDFI's research programme to produce improved planting stock, significant financial capital and land, along with skilled human resources, are all required if over 100 million trees are to be planted in the 10 years that follow. Therefore, from this point further efforts need to be focused on other critical elements required to achieve its vision. This includes providing information on rotation length, productivity and product yields that give existing or new landowners the confidence to invest in durable eucalypt forests, and ensuring sufficient management knowledge and labour is available to plant and manage the forests. However, the first big step is to get the best seedlings well planted into optimal sites so as to successfully establish new eucalypt forests for the future.

References

Barr, N. 1996. *Growing Eucalypt Trees for Milling on New Zealand Farms*. Wellington, NZ: NZFFA.

Eldridge, K. 1993. *Eucalypt Domestication and Breeding*. Oxford, UK; New York, US: Clarendon Press.

FAO. 2016. *Food and Agriculture Organisation of United Nations – Global Forest Products Facts and Figures 2016*. Rome, Italy: FAO.

Lin, H., Murray, T.J. and Mason, E.G. 2017. Incidence of and Defoliation by a Newly Introduced Pest, *Paropsisterna variicollis* (Coleoptera: Chrysomelidae), on Eleven Durable E*ucalyptus* Species in Hawke's Bay, New Zealand. *New Zealand Plant Protection*, 70: 45–51.

Millen, P. 2009. NZ Dryland Forests Initiative: A Market Focused Durable Eucalypt R&D Project. In Apiolaza et al. (Eds), *Revisiting Eucalypts*, 57–74. Wood Technology Research Centre, University of Canterbury, Christchurch, NZ.

Murray, T.J. and Li, H. 2017. Managing Eucalypt Pests in New Zealand: Optimised Monitoring and Selection for Tolerance. In Altaner et al. (Eds). *Durable Eucalypts on Drylands: Protecting and Enhancing Value*. Workshop Proceedings, April 2017, Blenheim, NZ. University of Canterbury: 39–53.

Potts, B.M., Sandhu, K.S., Wardlaw, T., Freeman, J., Li, H.F., Tilyard, P. and Park, R.F. 2016. Evolutionary History Shapes the Susceptibility of an Island Tree Flora to an Exotic Pathogen. *Forest Ecology and Management*, 368: 183–193.

Shelbourne, C.J.A., Bulloch, B.T., Low, C.B. and McConnochie, R. 2002. Performance to Age 22 Years of 49 Eucalypts in the Wairarapa District, New Zealand, and Review of Results from Other Trials. *New Zealand Journal of Forestry Science*, 32: 256–278.

Wardlaw, T. 2017. Managing the Health of Plantation Eucalypts in Tasmania. In Altaner et al. (Eds). *Durable Eucalypts on Drylands: Protecting and Enhancing Value*. Workshop Proceedings, April 2017, Blenheim, NZ. University of Canterbury: 26–38.

Paul Millen (Marlborough Research Centre), Shaf van Ballekom (Proseed NZ Ltd), Clemens Altaner (NZ School of Forestry), Luis Apiolaza (NZ School of Forestry), Euan Mason (NZ School of Forestry), Ruth McConnochie (Marlborough Research Centre), Justin Morgenroth (NZ School of Forestry) and Tara Murray (NZ School of Forestry). Corresponding author: p.millen@xtra.co.nz.