Forest&Wood Products Australia
Knowledge for a sustainable Australia

MARKET ACCESS

PROJECT NUMBER: PRA314-1314 May 2014

Cost-Benefit Analysis of Three Selected FWPA Projects

Contemporary Sound and Fire Rated Timber, Industry Standards for Recycled Timber & Utility of Molecular Breeding - April 2014

This report can also be viewed on the FWPA website
www.fwpa.com.au
FWPA Level 4, 10-16 Queen Street,
Melbourne VIC 3000, Australia
T +61 (0)3 9927 3200 F +61 (0)3 9927 3288
E info@fwpa.com.au W www.fwpa.com.au

Cost-Benefit Analysis of Three Selected FWPA Projects. Contemporary Sound and Fire Rated Timber, Industry Standards for Recycled Timber and Utility of Molecular Breeding - April 2014

Prepared for

Forest & Wood Products Australia

by

Ross McLeod

Publication: Cost-Benefit Analysis of Three Selected FWPA Projects. Contemporary Sound and Fire Rated Timber, Industry Standards for Recycled Timber and Utility of Molecular Breeding - April 2014

Project No: PRA314-1314

This work is supported by funding provided to FWPA by the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF).

ISBN: 978-1-921763-95-3

Researcher:
Ross McLeod
eSYS Development Pty Ltd
1/197 Pacific Highway,
Lindfield, NSW 2070

Forest & Wood Products Australia Limited
Level 4, 10-16 Queen St, Melbourne, Victoria, 3000
T +61 3 9416 7544 F +61 3 9416 6822
E info@fwpa.com.au
W www.fwpa.com.au

CONTENTS

CONTENTS 1

EVALUATION SUMMARY 2

CONTEMPORARY SOUND AND FIRE RATED TIMBER FRAMED CONSTRUCTION PRACTICES FOR LOW RISE BUILDING 5

INDUSTRY STANDARD RECYCLED TIMBER – VISUALLY GRADED RECYCLED DECORATIVE PRODUCTS 13

UTILITY OF MOLECULAR BREEDING IN FORESTRY 20

TERMS OF REFERENCE AND APPROACH 28

EVALUATION SUMMARY

What we did?

eSYS Development was engaged to undertake the evaluation of three randomly selected projects involving the development of contemporary sound and fire rated timber practices, interim standards for recycled timber grades and modelling the utility of molecular breeding (MOLEPLAN) in shining gum plantation forestry.

A cost-benefit framework was used to estimate the industry and spill-over impacts from the projects. Benefits quantified in the analysis include cost savings from timber construction in low rise density housing, increased profitability from accelerated achievement in tree improvement programs and savings from avoided landfill costs resulting from increased recycling.

Results of the cost-benefit analysis are summarized in the introductory section, then detailed evaluations are provided for each of the three projects. Projects are described in terms of their objectives, an outline of the research approach, key research outputs and an overview of project benefits. These benefits are then quantified in the final sections of each individual project analysis and compared against costs to determine economic returns.

How we did it?

Benefit projections were made using standardized time frames, a discount rate of 5 percent, and incorporation of a counterfactual scenario which accounts for research being delivered in the absence of FWPA support- albeit at a later point in time. The latest draft Guidelines for Evaluation of Research and Development, Version 1 - August 2012 were considered when determining attribution and counterfactual estimates

Attribution
Many factors contribute to the observed outcome of a research project. It is important to determine 'the extent to which the outcomes are directly attributable to the particular research output compared to the diversity of other factors that affect the final outcome.'[1] This is known as attribution. In each of the evaluations the possible contribution of other factors to outcomes are described in terms of other research and activities contributing to estimated outcomes.

Counterfactual
Defining the counterfactual scenario involves making an assessment about what research and outputs would have been developed in the absence of the project being evaluated. The latest evaluation guidelines note that 'in general, given the budget constraints facing research providers and funders, and the narrow range of options for funding rural research in Australia, an assumption that the R&D would have occurred anyway is not a sound counterfactual in the absence of compelling arguments to the contrary'. The basis for providing counterfactual scenarios are provided in each evaluation. For example, in the case of molecular breeding- which is a costly and strategic area of research - a counterfactual scenario of similar research outputs being produced in 30 years is included. For guidelines, such as those for fire and

[1] Draft Guidelines for Evaluation of Research and Development, Version 1 - August 2012

sound rating and recycled timber grading, a much shorter lead time is used in the counterfactual scenario.

Investment Criteria
Three investment criteria, being Net Present Value (NPV), Benefit Cost Ratio (BCR) and the Modified Internal Rate of Return (MIRR) were calculated for the three selected projects. Costs are subtracted from project benefits through time to calculate the NPV of a project. Where the NPV is positive, benefits are greater than costs and the investment can be considered economically attractive.

The benefit-cost ratio demonstrates the dollars of project benefit generated for each dollar invested. If a BCR of 3 is estimated, then the project is estimated to deliver $3 of benefit for each dollar of project cost. The IRR is the discount rate that generates a project NPV of zero. The modified internal rate of return includes an allowance for reinvestment. Interested readers can gain further background on this investment criteria in Kierulff, H. 2008. 'MIRR: A Better Measure.' *Business Horizons* 51(4), 321-329.

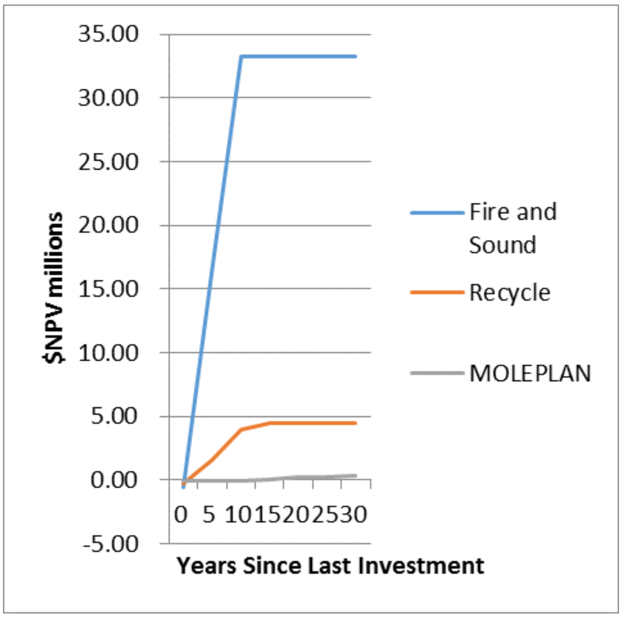

Figure 1: Projected Total NPV ($ millions)

Investment criteria, along with a description of project outputs and benefits underpinning these estimates are provided in each of the three case studies. The 2007 CRRDCC guidelines require NPV and other economic evaluation criteria be estimated for all project investment and for FWPA alone. These calculations are provided in each individual project assessment and are positive for both FWPA and partners using a 30 year projection. The large economic benefits generated for fire and sound practices are evident in the adjoining chart. Only a small cost saving in a relatively minor segment of the large value construction market generates considerable economic benefits for the fire and sound rating project. MOLEPLAN benefits are constrained by research focusing on a single species of plantation hardwood and the length of time between planting genetically improved material and harvest.

What we found?

Table 1 outlines the major pools of economic (industry profit), environmental and social benefits for each of the three projects. Benefits and costs are projected 30 years after the project was completed, using a five percent discount rate and detailed in present value terms (2014 dollars).

Table 1: Categories of Benefits from Selected Projects

	Contemporary Sound and Fire Rated Timber		**Industry Standards for Recycled Timber**		**Utility of Molecular Breeding**	
Benefit	**Levy paying industry**	**Spillover**[2]	**Levy paying industry**	**Spillover**	**Levy paying industry**	**Spillover**
Economic	Increased demand for timber products for single story town houses	Cost saving from decreased construction costs	Increased volume of recycled timber, leading to enhanced profitability		Greater probability of using more profitable molecular breeding techniques	
Environment				Decreased cost of landfill		
Social						
Total Present Value of Benefits (PVB) $million		34.02	3.04	1.70	0.89	
Total Present Value of Costs (PVC) $million	0.77		0.33		0.12	
Total Net Present Value (NPV) $million	33.25		4.42		0.77	
Benefit : Cost Ratio	44.00:1		14.54:1		7.17:1	

All three projects have positive net present values which indicates positive economic impact. Benefit-cost ratios for two of the projects are also larger than average RDC returns outlined in Productivity Commission and CRRDC reporting [3][4]. In these studies each dollar invested in RDC research was estimated to return around $10.51. Most economic benefits from the three selected projects stem from cost savings in low rise townhouse construction. Quantified environmental benefits are limited to avoided landfill costs flowing from reduced timber disposal as a result of increased recycling.

[2] Spillover's account for consumer, other industry and overseas benefits
[3] Council of Rural Research and Development Corporations 2010, Impact of Investment in Research and Development by the Rural Research and Development Corporations: Year 2 Results, Canberra
[4] Productivity Commission Inquiry Report. 2011. Rural Research and Development Corporations. No. 52, 10 February 2011. The Commission cited evaluations for the Council of Rural Research and Development Corporations (CRRDC 2010) calculating that each $1.00 invested in RDCs returned $10.51 after 25 years

CONTEMPORARY SOUND AND FIRE RATED TIMBER FRAMED CONSTRUCTION PRACTICES FOR LOW RISE BUILDING [5]

Background

Fire and sound rated timber represented $100 million of sales in Australia per year mainly for Multi Residential Timber Framed Construction (MRTFC). Much of this timber is used in low rise townhouse construction.

In addition to townhouse construction, emerging market opportunities in low rise commercial and institutional building markets (shops, offices, schools) were evident in the early 2000s. These buildings differ in having large open spaces – needing post and beam construction techniques – as opposed to close-spaced structural stud frames. Timber is not typically used in buildings of greater than 3 stories due to the use of masonry or concrete in lift shafts and problems with sound proofing and fire compliance.

The Timber Development Association (TDA) developed a series of industry manuals to support use of these products but they had not been updated for more than 5 years. These manuals were in need of revision due to changes in acoustic regulations, development of party wall systems and increased need for airborne noise abatement. Sound insulation is a key driver of construction system designs due to end-user demands for limited noise.

The aim of the project was to develop construction practice for low rise framed MRTFC buildings that are supported by reference in the Building Code of Australia. The project met FWPRDC objectives of stimulating profitable value-adding, manufacturing and re-engineering timber frame construction to appeal to a larger market, enhancing market opportunities and product marketability for wood products and promoting international best practice throughout the industry.

Project Objectives

- Develop 'state of the art' fire and sound rated timber frame construction practices for all low rise residential framed buildings.
- Expand fire and sound rated timber framing construction practices to include low rise commercial and institutional buildings; and
- Develop supporting documentation for the new technology in a form acceptable to end users, and undertake the background work to have the documentation referenced in the Building Code of Australia.

Project Description

A three stage methodology was employed to meet project objectives. The first stage involved updating construction practices by reviewing overseas state-of-the-art approaches, mainly in the United Kingdom, Canada, US, Scandinavia and New Zealand and surveying Australian stakeholders. An international literature review was conducted on new construction practices.

---

[5] PNA011-0708: Contemporary sound and fire rated timber framed construction practices for low rise building

A survey of users of timber framed construction was also conducted to determine key gaps in current Australian fire and sound rated timber construction practices. This involved in-depth interviews of 18 design and construction contractors, certifiers and building owners in Sydney, Melbourne and Brisbane. An industry workshop was conducted to develop action plans for priority needs raised in the survey and review. A total of 11 participants attended the workshop from organisation such as Bodycote Warrington, CSIRO, Boral, CSR, Lafarge, Winstone Wallboards, TDA and MiTek.

Fire testing regimes were developed to comply with the Building Code of Australia in the second stage of the project. Budget was originally set aside for six pilot tests and 6 full scale tests to confirm their compliance with appropriate building regulations. The needs analysis conducted in stage one identified that sound related elements of the project were being undertaken in New Zealand. The focus on the second stage was correspondingly reorientated towards fire testing.

In the third stage of the project fire and sound rated timber framed construction practices for reference in the BCA were published to be consistent with the Australian Building Codes Board for MRTFC - Class 1 (Townhouses), MRTFC - Class 2, 3, 9c (Apartments, hotels, motels, resorts and aged care) and Low Rise Commercial and Institutional Timber Framed Buildings - Class 5, 6, 9a and 9b (shops, offices, school) Building Classes. Manuals were prepared in a *Standards* format and published in electronic PDF form. Web based guides are available on www.woodsolution.com.au.

Financial and in-kind investments in R&D project

A summary of the financial resources invested by FWPA and Partners in this project is shown in Table 1.

Table 1: Investment in Project (nominal $)

Year Ended June	**FWPA**	**Partner**	**Total**
2006/2007	46,900	20,100	67,000
2007/2008	220,500	94,500	315,000
2008/2009	82,600	35,400	118,000
Total	350,000	150,000	500,000

Source: FWPA Proposal.

Research Outputs

The key output of the review was the patchy development of fire and sound rating practices focussing more on sound rather than fire resistant construction. The review noted the development of sound rated floor systems in the UK, use of Rockwool and standardisation of project drawings. Canadian studies identified the control of flanking noise using sound dampening layers on wall, ceiling and floor coverings. New viscoelastic products installed between wall and/or flooring were also being used in acoustic abatement. The project report recommended that future system development consider the cost and feasibility of floor systems with resilient top layers, using damping compounds, introducing anti-flanking sound detailing, increasing the use of Rockwool and providing drawing details as web downloadable CAD files.

The survey identified the choice of the "party wall" system as being a key solution. Systems employing a central membrane situated between stud walls were the most popular design. The double stud wall system was relevant where the central membrane approach creates an unacceptable width. There was limited demand for single stud wall frames. Respondents stated that guides must simplify detailing. This finding was also supported by workshop participants. It was noted that any new ideas needed to be readily integrated with trade packages and trade sequencing. There was also a need to focus on a limited number of methods.

A list of issues were highlighted for follow-up in the second phase of the project. They included solutions for subfloor fire rated wall construction, deep joist construction abutting, char factor calculations for fire rated walls, filling voids in fire rated systems, water and electrical penetrations, steel columns within separating walls supporting unrated steel beams, extension of the separation wall into the roof cavity (Class 1a), security of lightweight abutting wall systems, wet area retailing, eaves cavity detailing, roof battens details and acoustic tie data. Each matter was evaluated via fire performance, sound performance, holistic cost/benefit analysis build-ability, technology transfer and structural adequacy

Fire research in the second stage was examined from the standpoints of pure research into solutions for fire rated construction and verification of the final details to meet the Building Code of Australia (BCA). A formal assessment was obtained to support the separate requirements for sacrificial timber in construction joints. This was carried out for 60 and 90 minutes fire resistance. The 60 minutes systems uses timber blocks and 90 minutes light metal angles and timber blocks. Assessment based on a timber density of 450 kg/m3 was obtained. All work prior to this research project was based on radiata pine with a density of 550 kg/m3.

Data on lower timber density covered imported low density products such as Spruce Pine fir (SPF) and European pines. As already noted, the New Zealand consortium focussed on sound issues. The FWPA supported project did some investigations which highlighted acoustic improvement of a timber floor was a result of laying mass (concrete or sand) on the top surface.

The interpretation of "separation walls" resulted in project delay. The issue was resolved following consultation with the Australian Building Codes Board. Acoustic issues in the roof voids of townhouse construction were investigated and highlighted the requirement to discontinue the use of plasterboard systems. Rockwool blanket walls were studied but this line of research was ended during the course of the project due to a lack of compliance with BCA's Specifications.

The third stage involved dissemination of findings and development of explanatory guides. The BCA Compliant Sound and Fire Rated Timber Framed Construction – Construction Joints Utilising Sacrificial Timber Blocks was developed. It is based on the results of assessments, tests and opinions in the earlier stages of the project. The guides cover residential Building Classes (1a, 2 and 3), commercial (5 and 6) and institutional Building Classes (9a, 9b and 9c). Dissemination of results was via the use of a press release, magazine article, timber industry e-newsletter and contact with allied product industries. Guides are posted on the www.woodsolution.com.au site

Description of Innovation and Follow-on Development Costs

Fire and sound rated timber framed construction is used in residential townhouse construction, but there remains only a small share in 3 storey residential walk-up apartments and virtually no share in low rise office and retail building types. The project delivered updated guides, especially relevant for the single story townhouse market. The project report notes a major breakthrough was achieved by obtaining a formal assessment that removes the need to calculate fire loading conditions for wall stud sizing. Stud sizes are no longer a concern which will further the usage of timber when used in combination with fire systems. .

The project focussed on consolidating market share in the low rise market. The key benefit from using timber frames is that of cost, as masonry and structural steel construction are more expensive. Changed construction practices created a risk that existing market share would be lost should an up-to-date guide fail to be developed. Adoption of timber systems in three storey walk up buildings is still limited by low sound performance of floors and a suitable floor has was not obtained for this segment of the market. When estimating economic benefits, gains are calculated for single story construction. The guidelines have been developed and disseminated and there are no further follow-on costs.

Estimation of Benefits

Residential Building Market

In recent years the overall market has trended upwards, with building approvals increasing 3.1% in December and for the preceding 23 months. The value of residential building rose 2.2% and has risen for ten months (ABS, 2013).

Longer trends in new building approvals are outlined in Figure 1 using Australian Bureau of Statistics data. This data indicates that row houses, terrace houses, townhouses and apartment buildings have trended upwards, while single storey dwellings have steadily trended downwards in approval numbers.

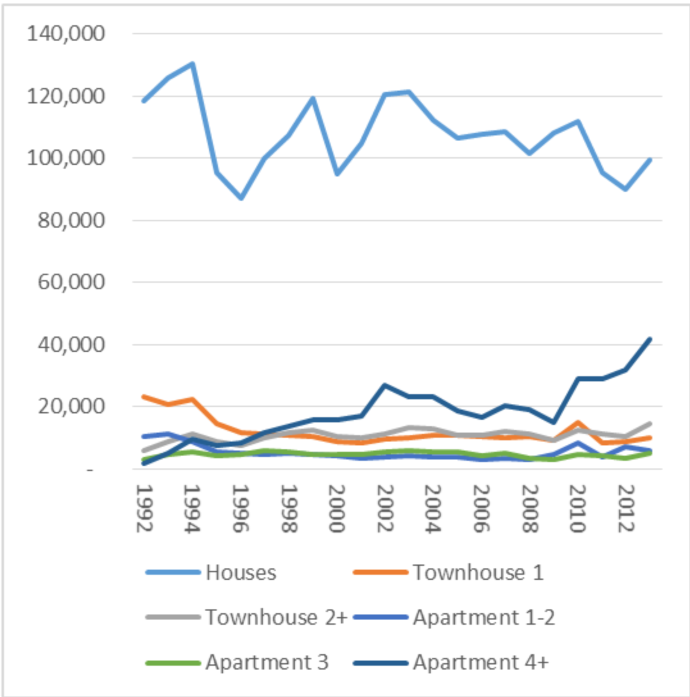

Figure: 1: Residential Building Approvals, Australia[6]

Potential Adoption

The single story semi-detached and townhouse sector is the major beneficiary of the guides. The number of new approvals has remained around 10,000 per year, of which 7,500[7] are timber. The feared decline in share due to the lack of fire and sound rating guidelines has not occurred. The project provided limited solutions for commercial buildings as there are no suitable products for fire rated timber framing above 90 minutes. Many of the building types

[6] Australian Bureau of Statistics (2013), 'Cat 8731.0 Building approvals", Australian Bureau of Statistics, Canberra

[7] The balance double brick and other non-timber construction methods

in Australian commercial construction require 120 or 180 minutes ratings. Sound issues precluded development of satisfactory flooring for multi-story apartments. Recently, multistorey timber apartments have been constructed using cassette systems, however, engineers associated with the project had to undertake considerable in-house research to development systems. These potential benefits are not included in the evaluation.

Construction Cost Saving

Timber is cost effective alternative to masonry and structural steel construction. Construction costs for a 150 m2 single story townhouse are estimated to vary from $250-300,000. A conservative saving of $10,000 is estimated where timber is used instead of masonry and structural steel construction. The saving is derived from labour and material cost savings. Not all the benefit from adoption can be attributed to this sole FWPA project. Guides had been produced in the past and the project has provided more simplified recommendations and fire solutions. Industry stakeholders consulted during the evaluation felt the guide had been of benefit to sustaining market share although the exact magnitude of the impact is difficult to quantify. Correspondingly, the project is assumed to have contributed 5% to the continued share of timber frames in the single story town house market.

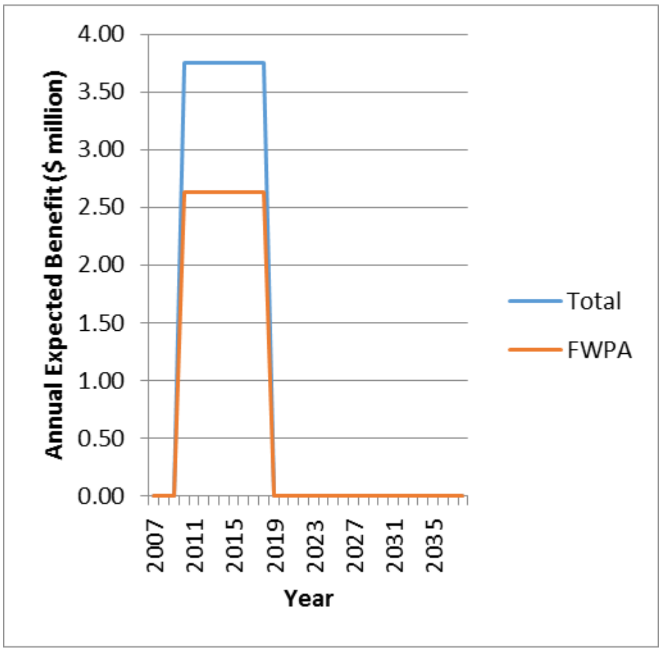

Figure 2: Annual Benefit Cash Flow

Counterfactual Scenario

A number of risks were identified in the project proposal. They included data risk, where attitudinal survey/interviews may not deliver useable outputs due to small sample size and also some technical data was to be derived using secondary sources. Test regimes for both sound and fire testing were considered sufficiently developed to prove adequate in developing evidence for BCA requirements.

These risks were overcome in project implementation. TDA has been a key proponent of MRTFC development in Australia for the last 15 years and is best placed to develop guidelines and fire and sound testing protocols. Discussions with industry suggest the guidelines are still valid and unlikely to become obsolete for some time. A counterfactual scenario with a lead time of 10 years is included in the cost-benefit analysis. This scenario presumes that a new guide would have been developed in the absence of FWPA support that would have helped sustained similar market share.

Table 2: Summary of Assumptions

Item	Assumption	Source
Cost savings from use of	$10,000	Consultant estimate based on 150m2

timber frame construction		single story townhouse size. The assumed floor space for a single story townhouse is assumed to be less than more common multi-story townhouses.
Number of single story townhouses, semi-detached and terrace houses constructed from timber per year	7,500	Derived from ABS (2013) approvals data and assumption that construction in some markets, such as WA, use double brick
Contribution of guide to continued use of timber construction in single story town houses	5%	Consultant estimate
Year adopted	2009	Year of project completion
Counterfactual	10 year lead time	Consultant estimate assuming guidelines will remain relevant for 10 years after initial dissemination

Results

The period of analysis was for 30 years after the last year of project investment. In total, a net present value of $33.3 million is estimated over a 30 year projection. A very high benefit cost ratio is estimated. At 44:1, this ratio indicates that for each dollar invested some $44 in construction cost savings have been achieved.

Table 3: Results of Cost-Benefit Analysis for Total Investment at 5% Discount Rate.

Investment criteria	**Period of Benefit (in Years from Last Investment in 2008/09)**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0.00	16.97	34.02	34.02	34.02	34.02	34.02
Present Value of Costs ($m)	0.60	0.77	0.77	0.77	0.77	0.77	0.77
Net Present Value ($m)	-0.60	16.20	33.25	33.25	33.25	33.25	33.25
Benefit–Cost Ratio	0.00	21.95	44.00	44.00	44.00	44.00	44.00
Modified IRR (%)[8]	nc	76%	48%	33%	26%	21%	19%

The results of the FWPA cost-benefit analysis are reported in Table 4. It is estimated that the NPV of the project from FWPA's investment is $23.3 million after 30 years. FWPA benefits are scaled in proportion to the allocation of FWPA's contribution to total project costs.

Table 4: Results of Cost-Benefit Analysis for FWPA Investment at 5% Discount Rate.

Investment criteria	**Period of Benefit (in Years from Last Investment in 2008/09)**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0.00	11.88	23.82	23.82	23.82	23.82	23.82
Present Value of Costs ($m)	0.42	0.54	0.54	0.54	0.54	0.54	0.54

[8] IRR is the Internal Rate of Return. Reinvestment rate of 5% used. Alston *et al* 2011 used a reinvestment rate similar to the discount rate for estimating benefit-cost ratios when assessing returns to publicly funded agricultural research in the USA.

Net Present Value ($m)	-0.42	11.34	23.27	23.27	23.27	23.27	23.27
Benefit–Cost Ratio	0.00	21.95	44.00	44.00	44.00	44.00	44.00
Modified IRR (%)[9]	nc	76%	48%	33%	26%	21%	19%

Sensitivity Analysis

The impact on investment returns resulting from changes in assumed percentage contribution (Table 5) of the project to low rise timber market share and construction cost saving (Table 6) are reported in the following tables. It is evident that the net present value of the project increases by nearly $24 million in the event that 10% of the benefits from sustained timber townhouse construction could be attributed to this project.

Table 5: Sensitivity of FWPA Investment
Criteria to Contribution of Guidelines to Sustained Market Share

Investment Criteria	1%	5 % (Base)	10%
PV of Benefits ($m)	4.76	23.82	47.63
PV of Costs ($m)	0.54	0.54	0.54
Net Present Value ($m)	4.22	23.27	47.09
Benefit Cost Ratio	8.80	44.00	88.01
Modified IRR (%)	13%	19%	21%

The net present value of the project is sensitive to the net benefit from estimated cost savings of timber construction. NPV also increases by $24 million if the cost savings was $10,000 per townhouse.

Table 6: Sensitivity of FWPA Investment
Criteria to the Benefit Received from Construction Cost Saving

Investment Criteria	$5,000	$10,000 (Base)	$20,000
PV of Benefits ($m)	11.91	23.82	47.63
PV of Costs ($m)	0.54	0.54	0.54
Net Present Value ($m)	11.37	23.27	47.09
Benefit Cost Ratio	22.00	44.00	88.01
Modified IRR (%)	16%	19%	21%

Conclusion

The absolute value of fire and sound rated timber used in single story townhouses and semi-detached construction are substantial, although this segment of the market is less than multi-story construction. The project successfully revised fire and sound guidance and recommendations to make them more usable by industry and up-to-date with current construction methods. This has helped sustain timber use in this market. Even a small contribution of the project to achieving this impact generates substantial economic benefits.

[9] IRR is the Internal Rate of Return. Reinvestment rate of 5% used. Alston *et al* 2011 used a reinvestment rate similar to the discount rate for estimating benefit-cost ratios when assessing returns to publicly funded agricultural research in the USA.

Acknowledgments

Andrew Dunn, Timber Development Association NSW
Tim Rossiter, MiTek
Darren Stock, Australand

References

Alston, J.M., Andersen, M.A., James, J.S., and Pardey, P.G. 2011. The Economic Returns to U.S. Public Agricultural Research ' *American Journal of Agricultural Economics* 93 (5), 1257-1277.

Australian Bureau of Statistics (2013), 'Cat 8731.0 Building approvals", Australian Bureau of Statistics, Canberra.

Industry Standard Recycled Timber – Visually Graded Recycled Decorative Products [10]

Background

Building materials account for about half of global solid wastes. In 2005 demolition waste in Australia was estimated to be 15.1 million tonnes, of which 7.6 million tonnes was recycled timber, steel, concrete, rubble and soil (WCS Market Intelligence, 2008). At this time there were no standards or recommendations for assigning design properties for structural reuse of wood and the use of recycled timber in decorative products.

Suppliers of recycled timber products used visual grading standards based on AS 2796 and AS 2082 which were developed for "new" timbers. Characteristics of recycled timber such as bolt, nail and screw holes; notches and discolouration are not normally found in new timbers and the strength of recycled product required consideration.

Reliable grading systems which account for the previous use of the timber have the potential to increase the efficiency of product marketing and end use. This need was identified by a review of the recycled timber industry in Queensland which noted the lack of grading rules as being one of the major impediments to the development and growth of this industry sector. Development of visual grading rules for a range of recycled timber products that address the specific characteristics of recycled timber was considered imperative at the time of this project's development.

Project Objectives

To develop a suite of new structural and decorative product specific grading rules that add to and are compatible with existing rules such as Australian Standards AS 2796, AS 2082 and AS 2858. The objective of the standard was to provide recycled timber manufacturers, suppliers and users with requirements for visually grading recycled hardwood timber intended for use in decorative applications.

Project Description

The project involved a review of international recycled wood grading practices, testing timber grades and disseminating interim standards to industry in a guidelines. The report on existing knowledge was to be developed by late 2006. A scoping survey and focus group meetings in Victoria and NSW were undertaken to compliment analysis undertaken in Queensland. The literature search and review had a focus on structural aspects.[11] Delays occurred in the early stage of the project due to a change of sub-contractor. As a result, the timing of the literature review and material testing schedule was later than planned.

Quantification of the strength reducing effects of timber characteristics was addressed during the testing stages of the project. Key characteristics including bolt holes which were treated as knots, effects of variable moisture content, notches and some natural defects - along with flexibility in tolerances and specific size availability were tested for strength. The testing program was designed to assess the extent to which aging and duration of load from previous timber use affected bending properties. Ninety pieces of timber (125 x 50 mm) cut from

[10] PN06.1039: Industry Standard Recycled Timber – Visually Graded Recycled Decorative Products
[11] It was known that over 1500 full size tests on recycled North American softwood had been performed

largely Structural Grade 2 girders were assessed during the first stage of testing. The structural capacity of timber from the compression side was compared to the tension side. The second stage of testing focussed on timber columns and flooring with characteristics such as spike holes, bolt holes, checking and natural features. Test results were included in the interim grading rules.

A second round of state focus group review meetings were held in Melbourne, Sydney and Brisbane to discuss interim standards and testing results. Industry input was noted in milestone reports as being mixed and contentious. In addition to the interim standards, span tables for structural recycled timber were also produced for a number of common applications. Technology transfer was conducted, with a paper on interim rules being presented at the WCTE Conference in Japan on 4th June 2008 at which key Australian peers were present. Results were also presented to a national conference on sustainable procurement in Brisbane in September 2008.

Financial and in-kind investments in R&D project

A summary of the financial resources invested by FWPA and Partners in this project is shown in Table 1. Variations from the proposal include an increase of $15,828 due to increase of in-kind resulting from greater material contributions, evaluation of the hand held MOE grader and sub-contractor in-kind contributions. Cash contribution to the project increased by $10,000 to account for the variation approved to produce span tables and disseminate findings at an industry conference.

Table 1: Investment in Project (nominal $)

Year Ended June	**FWPA**	**Partner**	**Total**
2007	58,830	83,345	142,175
2008	3,058	44,315	47,373
2009	10,000	-	10,000
Total	71,888	127,660	199,548

Source: FWPA Proposal and Audited Statements

Research Outputs

The literature review found that a significant amount of research has had been undertaken in North America to address challenges to the use of recycled timber. Research investigated the various ways timber properties change during usage. Much of the testing appeared to focus on Douglas Fir which underpinned the need to undertake testing on Australian grown hardwoods.

Outputs of the testing conducted in this project were detailed in the December 2007 report by University of Technology Sydney "Development of Visual Grading Rules for Recycled Timber – Report on Testing for Timber Queensland". It provides analysis and recommendations for recycled timber over 26 pages covering stiffness and strength testing results.

Key results included that "based on pooled analyses for sawn wharf timbers, it is observed that the 5th percentile characteristic strength for all the recycled members (irrespective of extraction location) is approximately 45 MPa, which is about 56% of the strength for new F27 timbers.….An estimate of 60% of new strength is probably appropriate". Circular "notches" within 30mm from an edge were found to have a non-significant impact on bending, but require consideration for axial loads. Compression tests were undertaken on short length posts manufactured with boxed in heart, largely from Spotted Gum and Ironbark. The tests suggest this timber can be treated as new.

Based on the findings of strength testing it was concluded that MoR values should be reduced by 35% for recycled timbers derived from roof structures with light weight cladding, 50% for timber with a longer load history such as warehouse and wharf storage floors, and if the loading history is not known then a reduction of 55% of new timber strength for the same visual grade should be used.

The project dealt with the complexities of producing concise grading rules for the industry. The rules are included in a draft Interim Industry Standards to meet project objectives, but also reflect the philosophical differences expressed during stakeholder working group meetings. An interim standard was adopted "to provide an orderly introduction into the marketplace, within a shorter time frame than would be possible implementing using the "Standards" development process".

Given recycled hardwood does not fit within the 'F' grade system for 'new' timber, a variation in project outputs was approved by FWPA to produce a set of span tables using specific recycled hardwood timber properties as recommended in the final draft of the structural recycled rules. This variation extended the final project completion date to November 2008.

Description of Innovation and Follow-on Development Costs

An interim standard was developed for grading, along with a span table. The standard was disseminated at conferences and is available as a downloadable document. No further development costs are required for the interim recommendations. The major anticipated benefit of the project was enhanced use of recycled timber products in the market place, whilst at the same time providing appropriate standards for defining "fit for use applications" and ensuring safe characteristic properties are used by designers when using recycled timber members in structural applications. Discussion with some industry players suggest there has been increased use of recycled timber products which has generated increased profits for industry and decreased costs associated with the disposal of timber as landfill.

Estimation of Benefits

Increased industry profitably had flowed from adding value to timber products and greater recycling of timber. The benefits from the increased volume of recycled timber stemming from the development of interim standards is difficult to estimate given the wide range of sources and end uses for recycled product. The Commonwealth Department of Sustainability, Environment, Water, Population and Communities (2011) indicated that retail prices can be as high as $1,000 per m3 for recycled hardwoods. For the purposes of this analysis it is estimated that average retail value of around $500 m3 is achieved, along with a profitability margin of 15%.

Increased use of recycled products also has positive economic benefits through reducing landfill. The cost of landfill in Australia ranges from $42 to $102 per tonne (Commonwealth Department of Sustainability, Environment, Water, Population and Communities, 2011). In New South Wales the government landfill levy ranges between $20 and $70 per tonne. (NSW

Office of Environment and Heritage, 2011). An avoided cost of landfill of $42 m3 is included as a benefit in the cost-benefit framework.

Potential Adoption

Recycled timber is sourced from power poles, buildings and other structures. In 2009 the volume of re-used timber was estimated to be around 60 000 cubic metres (Commonwealth Department of Sustainability, Environment, Water, Population and Communities, 2011), although this volume most likely accounted for hardwood and other sources of recycled timbers. For example, power pole recycling from Spotted Gum, Ironbark, Blackbutt, Grey Box, Tallow Wood and Blood Wood is conducted by Kennedy's Timber, which results in recovery of 40 percent following sawing, drying, docking and dressing. This company was processing approximately 6000 m³ of poles and cross arms per year at the time of the publication of the above 2011 report.

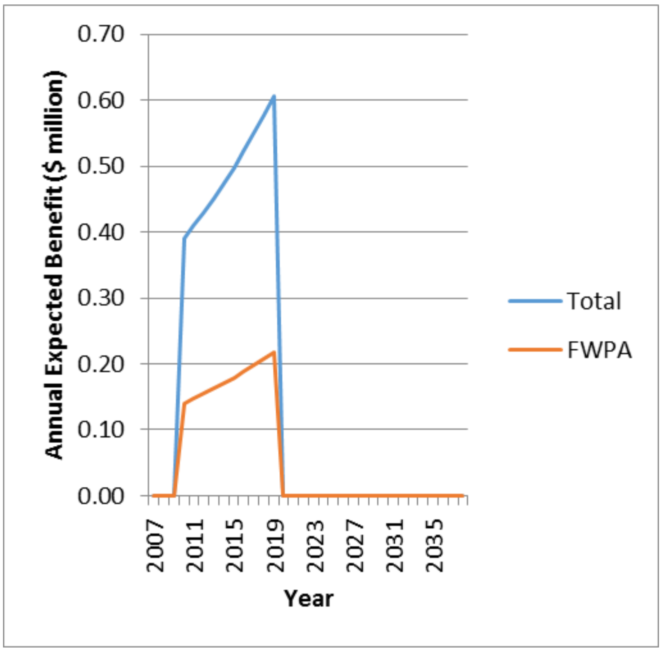

Figure 1: Annual Benefit Cash Flow

Around 10,000 to 12,500 of the two million wooden poles installed in New South Wales are declared redundant and replaced each year. It is estimated that a total of 18,000 m3 of power poles are processed per year. Power poles are estimated to account for around a quarter of the hardwood recycle market. Discussion with industry indicated that the volume of reuse timber is generally increasing. Commonwealth Department of Sustainability, Environment, Water, Population and Communities (2011) note a barrier to increasing volume in the re-use market is the increasing mechanisation of demolition works which can damage high-value timbers. It is estimated that the recycled hardwood market is growing by 5 percent per year.

Counterfactual and Contribution

The interim guidelines have been developed and disseminated to industry, so the risks of developing an output have been overcome. There were conflicting opinions about the appropriate nature of grading rules expressed during industry workshops in the project and also during feedback provided in this evaluation. Correspondingly, it is estimated that only a minor portion of the benefits from recycled hardwood volumes can be attributed to the project. This is estimated to be 10%.

In the absence of the project it is possible that guidelines may have been developed by industry independent of FWPA support. For example, the Department of Environment, Climate Change and Water NSW (DECCW) funded the Timber Development Association (NSW) to develop a protocol to increase recycling of redundant utility poles and bridge timbers in the state in 2008. A lead time of 10 years is included to account for this possibility.

Table 2: Summary of Assumptions

Item	Assumption	Source
Volume of power poles recycled per year	18,000 m3	Consultant estimate. Only a minor portion of the total timber pole stock is recycled given stock estimates in Francis and Norton 2006
Recoverable hardwood from power poles	40%	Commonwealth Department of Sustainability, Environment, Water, Population and Communities (2011)
Saleable hardwood from power poles	7,200 m3	Estimate derived from assumption of recoverable product and poles recycled
Cost of landfill	$42 per m3	Commonwealth Department of Sustainability, Environment, Water, Population and Communities (2011)
Retail price of recycled power poles timber	$500 per m3	Consultant estimate
Net benefit margin of recycled power poles timber	15%	Consultant estimate
Other recycled timber products (bridges and buildings)	54,000 m3	Consultant estimate assumes other products are three times the volume of power poles. Most timber is generated from the demolition sector Commonwealth Department of Sustainability, Environment, Water, Population and Communities (2011). Margins and prices assumed to be similar to power poles
Saleable hardwood from other sources such as demolition	21,600 m3	Assumes 40 percent recovery for other sources
Growth in recycled hardwood volume per year	5%	Consultant estimate
FWPA project contribution	10%	Consultant estimate
Year adopted	2009	Interim standards and span tables published in this year
Counterfactual	10 year lead time	Consultant estimate assuming standards would have been developed by the Australian industry in 10 years without the project.

Results

The period of analysis was for 30 years after the last year of project investment. In total, a net present value of $4.42 million is estimated over a 30 year projection. A benefit-cost ratio of 14.54:1 is calculated.

Table 3: Results of Cost-Benefit Analysis for Total Investment at 5% Discount Rate.

Investment criteria	Period of Benefit (in Years from Last Investment in 2008/09)						
	0	5	10	15	20	25	30

Present Value of Benefits ($m)	0.00	1.90	4.27	4.74	4.74	4.74	4.74
Present Value of Costs ($m)	0.31	0.33	0.33	0.33	0.33	0.33	0.33
Net Present Value ($m)	-0.31	1.57	3.94	4.42	4.42	4.42	4.42
Benefit–Cost Ratio	0.00	5.81	13.08	14.54	14.54	14.54	14.54
Modified IRR (%)	nc	41%	33%	24%	19%	16%	14%

The results of the FWPA cost-benefit analysis are reported in Table 4. It is estimated that the NPV of the project from FWPA's investment is $1.53 million after 30 years.

Table 4: Results of Cost-Benefit Analysis for FWPA Investment at 5% Discount Rate.

Investment criteria	**Period of Benefit (in Years from Last Investment in 2008/09)**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0.00	0.68	1.54	1.71	1.71	1.71	1.71
Present Value of Costs ($m)	0.17	0.18	0.18	0.18	0.18	0.18	0.18
Net Present Value ($m)	-0.17	0.51	1.36	1.53	1.53	1.53	1.53
Benefit–Cost Ratio	0.00	3.85	8.66	9.62	9.62	9.62	9.62
Modified IRR (%)	nc	31%	28%	21%	17%	15%	13%

Sensitivity Analysis

The impact on investment returns resulting from changes in contribution of the FWPA standards to recycled hardwood sales (Table 5) and net benefit margin (Table 6) are reported in the following tables. It is evident that the net present value of the project decreases by $0.85 million in the event that 5% of the benefits from recycled hardwood be attributed to this project.

Table 5: Sensitivity of FWPA Investment
Criteria to Contribution of Project to Recycled Sales

Investment Criteria	**5%**	**10 % (Base)**	**30%**
PV of Benefits ($m)	0.85	1.71	5.12
PV of Costs ($m)	0.18	0.18	0.18
Net Present Value ($m)	0.68	1.53	4.95
Benefit Cost Ratio	4.81	9.62	28.85
Modified IRR (%)	10%	13%	17%

It is evident that the net present value of the project is sensitive to the net benefit margin. NPV increases by $1 million if the net benefit margin increased from 15 to 30 percent.

Table 6: Sensitivity of FWPA Investment
Criteria to Percentage Net Benefit Margin

Investment Criteria	**5%**	**15% (Base)**	**30%**

PV of Benefits ($m)	0.98	1.71	2.80
PV of Costs ($m)	0.18	0.18	0.18
Net Present Value ($m)	0.80	1.53	2.63
Benefit Cost Ratio	5.51	9.62	15.78
Modified IRR (%)	11%	13%	15%

Conclusion

The development of a suite of new structural and decorative product specific grading rules is estimated to generate considerable economic benefits. A relatively conservative assumption of the project contributing to 10% in recycled hardwood sales was used in the analysis as not all suppliers are using the grading rules. Even with this assumption, the project was estimated to generate a benefit-cost ratio of 9.62:1, which suggests that for every dollar invested, industry returns in the order of $9.62 are generated. Considerable economic benefits were also calculated from the avoidance of landfill. Demolition is a large contributor to solid waste, which costs more than $40 per tonne.

Acknowledgments

Andrew Brodie, Australian Architectural Hardwoods
Michael Kennedy, Kennedy's Timbers
Colin McKenzie, Timber Queensland

References

ABARES (2013), Agricultural commodities: December quarter 2013, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra

Commonwealth Department of Sustainability, Environment, Water, Population and Communities (2011) Construction and demolition waste guide, AGPS, Canberra.

Francis, L. and Norton, J. 2006. Australian Timber Pole Resources for Energy Networks A Review. Department of Primary Industries & Fisheries, Queensland

Fridley, K.J, Williams, J.M. & Cofer, W.F. (2001), "Reliability of reused sawn lumber: effect of fastener holes", *Journal of Structural Engineering*, April, pp.412-417

NSW Office of Environment and Heritage (2011) Protocols for recycling redundant utility poles and bridge timbers in New South Wales, Office of Environment and Heritage NSW (OEH), Department of Premier and Cabinet and Timber Development Association (NSW

WCS Market Intelligence, 2008, The Blue Book: Australian waste industry: 2007/08 industry and market report, North Sydney, N.S.W. WCS Market Intelligence, 114 p

UTILITY OF MOLECULAR BREEDING IN FORESTRY [12]

Background

Tree improvement is fundamental for improving productivity and returns in plantation forestry. Genetic gains in the production of plantation hardwoods have been achieved by selecting for a range of growth and wood quality traits based on predictions of the genetic merit of a tree in field and commercial trials. Gunns Limited and Forestry Tasmania have been running these types of conventional tree improvement programs for *Eucalyptus nitens* for more than three decades.

Industry and governments have invested heavily over several decades in developing molecular technologies, such as markers, with little commercial return to industry. Molecular markers are DNA sequences that have a known location on a chromosome and may be associated with a particular trait. Using markers and high throughput testing, seedlings carrying genes associated with the desired characteristics can be identified, rather than waiting for many growing season and screening many hundreds or thousands of plants for desired phenotypic properties (Stoutjesdijk and ten Have, 2013). This has the potential to accelerate the genetic gain of conventional improvement programs.

Trials have been conducted to identify markers in *Eucalyptus nitens*. Markers have been used in fingerprinting to check pedigree error rates in breeding and deployment populations. Developing marker technologies is expensive, and to date, much investigation had been driven by a research agenda with little consideration for operational breeding and how the technologies fit within a broader multi-trait situation. While the marker assisted approach promises efficiencies in some circumstances, these need to be balanced against gains that can be delivered from proven technologies.

The economic value of integrating molecular approaches into more conventional breeding required investigation. The aim of this research was to investigate the integration of molecular data into routine genetic evaluation of one species, *Eucalyptus nitens,* commonly known as Shining gum, using the software program TREEPLAN (PCN03-1915 and PNC076-0809). Shining gum was selected as it is an important plantation species grown in Tasmania and some areas of Victoria and marker-trait associations had been found for this species as part of the FWPA-supported Hottest 100 project.

Project Objectives

The aim of the project was to investigate the integration of molecular data into routine genetic evaluation of plantation species such as *Eucalyptus nitens*:

- Integrate molecular based selection criteria with phenotypic data for E. nitens in a species wide TREEPLAN analysis.
- Determine the utility of molecular information in improving genetic gain for an economic objective based on multiple traits.
- Disseminate results and findings to the Australian forestry industry

[12] PNC220-1011: Utility of molecular breeding in forestry

Project Description

Single nucleotide polymorphisms (SNP) have been identified which are associated with variation in Kraft Pulp Yield (KPY) and cellulose content (CC) and may explain in excess of 10% of the total additive genetic variation. The molecular-based trait was included in a multivariate analysis by treating it as if it were a conventional (field-based) trait, with a genetic and error variance, and genetic co-variances with other traits.

The Southern Tree Breeding Association (STBA) has developed a comprehensive genetic evaluation system (TREEPLAN) that is capable of analysing in excess of a hundred traits, measured across potentially hundreds of progeny trials using a multi-trait and multi-site best linear unbiased prediction model customised for forest tree data (Kerr et al 2012). The approach used in this project required no substantial changes to current software.

Predicted genetic values for molecular- and field-based traits were multiplied by their economic weights to form a prediction of the index value. Routine evaluation without genomic information was firstly conducted, then genomic effects estimated using adjusted phenotypes arising from the first step.

Using data generated from the analysis the economic value of including markers in conventional evaluation were estimated. These results were disseminated to industry (Gunns Limited and Forestry Tasmania) and documented in the project report. The work has been presented at an industry genome roundtable held in July 2011 in association with the Botanical Congress, Technical Advisory Committee meetings in 2011, along with general findings presented at the AusTimber 2012 ForestWorks conference in Mount Gambier.

Financial and in-kind investments in R&D project

A summary of the financial resources invested by FWPA and Partners in this project is shown in Table 1.

Table 1: Investment in Project (nominal $)

Year Ended June	FWPA	Partner	Total
2010/2011	30,000	70,000	100,000
Total	30,000	70,000	100,000

Source: FWPA Proposal.

Research Outputs

Molecular based selection criteria were generated using data from the Hottest 100 project and integrated with data from 151 field trials in the DATAPLAN system. Evaluation was undertaken using a subset of 27 of these trials. Results indicate that a panel of SNP explaining as little as 8% of the total additive variance for a selection criteria trait has practical benefit within the context of screening genotypes for use in deployment.

In the final report it was noted the results need to be treated with some caution as the sample used for the study may not adequately represent the complete *E. nitens* population and more validation is required if screening is to be attempted in other sub-races. The current study is, however, a milestone achievement because it is the first time the added value from the use of molecular (SNP) data in an operational tree improvement program has been economically quantified. It showed molecular data can be used to complement conventional tree breeding methods based on quantitative genetics and phenotypic data. The molecular based selection criteria are available in DATAPLAN for further TREEPLAN evaluations as new phenotypic data is generated.

Description of Innovation and Follow-on Development Costs

The study demonstrated for the first time in an operational tree improvement program that molecular information can make an incremental contribution to genetic and economic gain when coupled with phenotypic tree breeding data. The study also underpinned the utility of the TREEPLAN genetic evaluation system. Molecular information has the potential to increase marginal profit due to improved genetics (not total productivity) by a further 10 percent, based on the results from the study. There will be follow-on costs in incorporating markers into breeding programs. The exact nature of these costs is not known given the strategic nature of the research. Commercial breeding program costs were included in the Treeplan model to estimate follow-on costs. These are included in the marginal financial benefits estimates provided in the next section.

Estimation of Benefits

By integrating the molecular based selection criteria in the TREEPLAN evaluation, an additional 10 percent or incremental gain of $55/ha NPV per hectare can be achieved over conventional breeding, where a gain in the order of $557/ha NPV have been calculated using the TREEPLAN system. The gain of $55/ha NPV is the marginal gain or extra profit due to the use of markers. This assumptions underpinning this estimates are commercial-in-confidence, and only global results are provided in the end-of-project report.

Potential Adoption

Shining gum is an important plantation species grown in southern Australia, with project commercial partners Gunns Limited and Forestry Tasmania supporting conventional improvement programs for this species over many years. The objective of the programs has been to improve tree characteristics which are important commercially, such as growth rate, tree form, wood and fibre quality, disease and pest tolerances. Results from the conventional program were integrated with marker data from the Hottest 100 project in TREEPLAN.

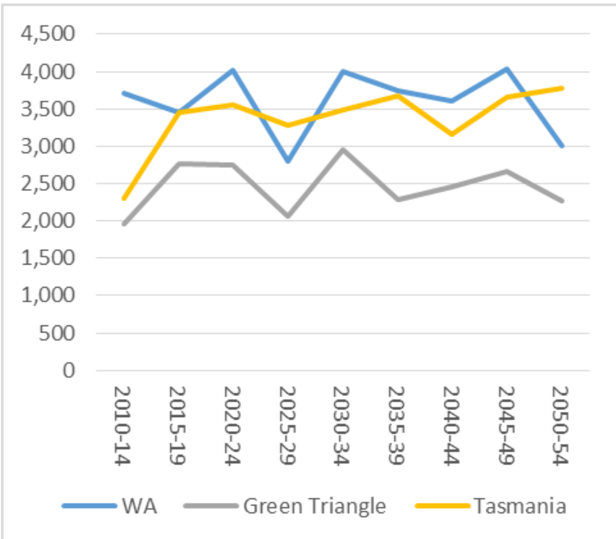

Figure 1: Hardwood Pulp Projections by State ('000 m3), Source: Gavran *et al* (2012)

Given the focus of the project on this species, economic benefits in this cost-benefit study are calculated solely for *E. nitens*. Given there are likely to be benefits from the integration for other plantation species, this assumption likely results in benefits of the project being understated as the analysis is only conducted for *E.nitens*. Broadleaf production is dominated by blue gum (*E. globulus*, 55 per cent) and shining gum (*E. nitens*, 24 per cent), grown for pulpwood. The percentage of hardwood plantations destined for pulpwood has remained constant in recent years at 84 per cent in 2011–12.

Table 2: Major Broadleaved Species by Region; 2011-12

	Blue Gum	**Black-butt**	**Shining Gum**	**Spotted Gum**	**Dunns Gum**	**Other**	**Total**
	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha
Western Australia	277			1		23	301
Green Triangle	171						171
SE Queensland		2		6	19	4	31
North Coast NSW	1	22	4	13	27	16	83
Central Victoria	33		3			2	38
Central Gippsland	14		11			8	33
Tasmania	20		208			8	236
Other	19	2	10	2	1	49	84
Australia	**535**	**26**	**236**	**22**	**47**	**110**	**977**
Percent	**55%**	**3%**	**24%**	**2%**	**5%**	**11%**	**100%**

Source: Garvan (2013)

Most shining gum plantations are in Tasmania. It is popular in these areas due to its growth rate and ability to grow in cold and dry areas at high elevations. Broadleaved pulpwood production in Tasmania forecast by Gavran *et al* (2012) is that it will be relatively stable. The forecast assumes that harvested areas will usually be replanted with the same type of plantation species. Production is calculated to remain relatively stable around 3.5 million m^3. Corresponding with this forecast the current plantation area of 236,000 hectares is assumed for the economic analysis and is held constant over the projection period.

Adoption of improved *E. nitens* tree stock is governed by this species harvesting cycles and expansion in the plantation area. Given this species is harvested after 15 years, an annual planting of 7% of the plantation area is included in this analysis. Based on a 15 year cycles, an annual replanting of 16 thousand ha per hear with seedlings is assumed from 2014.

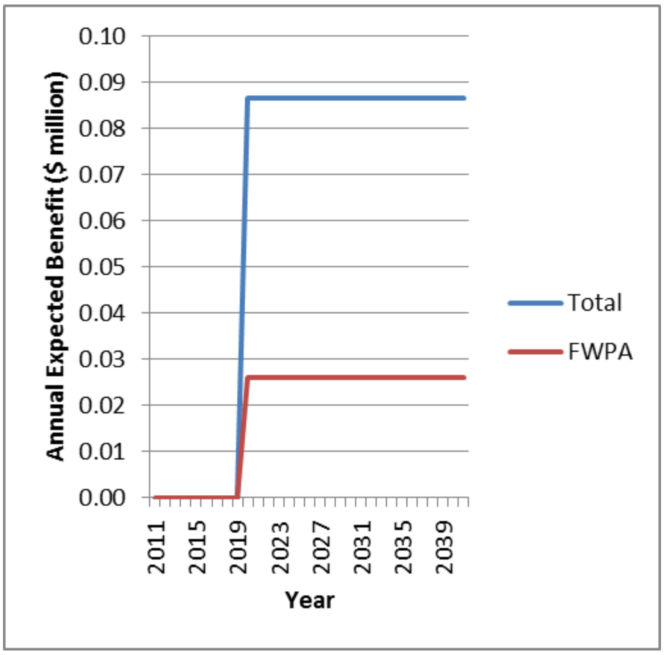

Figure 2: Annual Benefit Cash Flow

Attribution

The project has demonstrated the potential value of molecular approaches to breeding. Molecular data from the Hottest 100 project was combined with phenotypic data in the DATAPLAN system. This has demonstrated the potential value of the marker based approach. As a result it is more likely molecular approaches will be pursued by industry. Correspondingly 20% of benefits from the adoption of markers in *E.nitens* genetic improvement are attributed to this FWPA-supported project.

Probability of Success
The project was successful in integrating molecular data into routine genetic evaluation of *Eucalyptus nitens*. There are some risks associated with the realisation of economic benefits. Firstly, the SNP-trait associations were discovered using two sub-races that may not adequately represent the whole *E. nitens* resource. Much of investigation into markers has been research driven - seeking to identify candidate genes and understand gene function. This approach may not deliver benefits for traits affected by many genes. There is a need to also deal with the aggregated genome rather than discovering genes or genomic regions and their individual effects.

The project did not weigh up spending extra money of collecting phenotypic data verse spending money on marker data. Until that analysis is done, the approaches cannot be directly compared and thus recommendations about adoption have some uncertainty. There has been a decrease in research investment in the forest sector in the 10 years to 2008. Turner and Lambert (2010) indicated expenditure on forestry research in Australia has declined 0.45 % per year in real terms.

There is a risk that vital capacity and resources required to undertake highly technical analysis may be lost. It is estimated that marker approaches to tree improvement will not be incorporated in deployed seedlings until 2020. A probability of success (50 percent) was included in the cost-benefit analysis that industry would use the research, despite the risks of sustained research capacity and funding.

Counterfactual.
The amount of useful molecular data is currently very limited, however, the Hottest 1000 project is seeking to expand the information base. Given the strategic nature of the research and time taken to include marker in commercial breeding programs it is estimated that there would be a substantial lead before similar technology would be adopted by industry in the absence of this project. The lead is estimated to be 30 years.

Table 2: Summary of Assumptions

Item	Assumption	Source
Net present value of *E.nitens* profitability with the integration of makers in breeding programs	$55/hectare	Taken from Kerr *et al* (2012).
E.nitens plantation area	236 thousand hectares	Garvan (2013)
Growth in plantation area	Stable	Hardwood output projected to be steady by Garvan *et al* (2012)
Rate of Adoption	7% per year	Based on plantation production cycle of 15 years
Attribution	20%	Consultants estimate that 20% of benefit can be attributed to this investment
Year Adopted	2020	Consultants estimate based on lag to allow marker technology to be integrated in breeding program
Probability of Success	50%	High probability of success assumed as

		Hottest 100 data demonstrates production benefits.
Counterfactual	30 year lead time	Consultant estimate based on strategic nature of marker technology.

Results

The period of analysis was for 30 years after the last year of project investment. In total, a net present value of $0.77 million is estimated over a 30 year projection. The difference between costs and benefits is the net present value. The benefit-cost ratio is 7.17, which indicated that for every dollar invested in the project is calculated to return $7.17 in industry benefits.

Table 3: Results of Cost-Benefit Analysis for Total Investment at 5% Discount Rate.

Investment criteria	**Period of Benefit (in Years from Last Investment in 2010/11)**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0.00	0.00	0.13	0.39	0.60	0.76	0.89
Present Value of Costs ($m)	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Net Present Value ($m)	-0.12	-0.12	0.00	0.27	0.48	0.64	0.77
Benefit–Cost Ratio	0.00	0.00	1.01	3.15	4.83	6.14	7.17
Modified IRR (%)	nc	nc	9%	14%	13%	13%	12%

The results of the FWPA cost-benefit analysis are reported in Table 4. It is estimated that the NPV of the project from FWPA's investment is $0.23 million after 30 years. FWPA benefits are scaled in proportion to the allocation of FWPA's contribution to total project costs.

Table 4: Results of Cost-Benefit Analysis for FWPA Investment at 5% Discount Rate.

Investment criteria	**Period of Benefit (in Years from Last Investment in 2010/11)**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0.00	0.00	0.04	0.12	0.18	0.23	0.27
Present Value of Costs ($m)	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Net Present Value ($m)	-0.04	-0.04	0.00	0.08	0.14	0.19	0.23
Benefit–Cost Ratio	0.00	0.00	1.01	3.15	4.83	6.14	7.17
Modified IRR (%)	nc	nc	9%	14%	13%	13%	12%

Sensitivity Analysis

The impact on investment returns resulting from changes in the estimated NPV per hectare from accelerated improvements in tree breeding (Table 5) and net benefit from enhanced stumpage value (Table 6) are reported in the following tables. It is evident that the net present value of the project increases by nearly $0.3 million in the event that the NPV of improved breeding increased to $110 per hectare.

Table 5: Sensitivity of FWPA Investment
Criteria to NPV (Net Present Value) of Improved Breeding

Investment Criteria	**$28 per ha**	**$55 per ha (Base)**	**$110 per ha**
PV of Benefits ($m)	0.13	0.27	0.54
PV of Costs ($m)	0.04	0.04	0.04
Net Present Value ($m)	0.10	0.23	0.50
Benefit Cost Ratio	3.59	7.17	14.34
Modified IRR (%)	10%	12%	15%

The net present value of the project is similarly sensitive to the net benefit from estimated contribution of the project to improved breeding adoption. The modelling project would need to contribute to the adoption of molecular techniques by 3 percent for the project to breakeven.

Table 6: Sensitivity of FWPA Investment
Criteria to the Estimated Contribution of the Project to Improved Breeding

Investment Criteria	**10%**	**20% (Base)**	**30%**
PV of Benefits ($m)	0.13	0.27	0.40
PV of Costs ($m)	0.04	0.04	0.04
Net Present Value ($m)	0.10	0.23	0.36
Benefit Cost Ratio	3.59	7.17	10.76
Modified IRR (%)	10%	12%	14%

Conclusion

The modelling project has demonstrated that molecular breeding approaches have the potential to accelerate genetic gain in *E.nitens* improvement programs Modelling suggests that the current genetic gain, which generates an increased profit of more than $500 per hectare on a net present value basis, could be increased by a further 10 percent using marker approaches. This information is assumed to assist industry uptake of molecular techniques. Modelling would only need to contribute to this uptake by 3 percent for the project to breakeven. While the marker assisted approach promises efficiencies in some circumstances, this need to be balanced against gains that can be delivered from other proven technologies. A detailed comparative cost-benefit analysis is therefore needed. The Hottest 1000 project will provide additional data and this should be incorporated in TREEPLAN evaluation in due course.

Acknowledgments

Greg Dutkowski, PLANTPLAN and University of Tasmania
Tony McRae, Southern Tree Breeding Association
Dean Williams, Forestry Tasmania

References

ABARES (2012), Australia’s forests at a glance 2012, ABARES, Canberra, August

Gavran, M (2013), Australian plantation statistics 2013 update, ABARES technical report 13.3, Canberra, May

Gavran, M, Frakes, I, Davey, S and Mahendrarajah, S, (2012), Australia's plantation log supply 2010–2054, ABARES, Canberra, March

Kerr, R.J., G.W. Dutkowski, T.A. McRae, S. Southerton, B. Thumma and B. Tier (2012) Utility of molecular breeding in forestry, FWPA Project Report. Project No PNC220-1011.

Singh, S, Cunningham, D, Davidson, J, Bush, D and Read, S (2013), Status of Australia's forest genetic resources, ABARES research report 13.3, Canberra, February

Stoutjesdijk, P and ten Have, J (2013), Using enabling technologies to meet demands for food security and sustainability, ABARES technical report 13.08, Canberra, November

Turner, J and Lambert, M (2010), 'Expenditure on forestry and forest products research in Australia 2007-2008', *Australian Forestry*, 74(2), pp. 149–155

TERMS OF REFERENCE AND APPROACH

Task: To undertake an ex-post evaluation of three Forest & Wood Products Australia research projects.

Output: The main output from this consultancy will be a report (and accompanying spreadsheets) that details:

- Key outputs for each of the projects
- Technology (product, process or information) that has been made available to industry, and if appropriate, the required steps from project completion until such technologies are commercially available;
- Economic, social and environmental benefits to technology users, industry, and Australia (spill-over to other parts of the supply chain and community) with key assumptions summarized. Industry benefits for levy payers to be considered include:
    - the value of improvements in productivity
    - the value of improvements in market share or market returns
    - the value of improving market access
    - the value in reducing risk or improving the sustainability of the business; and
    - the value of improved industry awareness.
- Expected adoption rate through time with consideration of factors likely to limit or enhance take-up
- The counterfactual scenario will be modeled. The scenario considers what would have happened in the absence of the project. (eg. has research bought forward a benefit?)
- Uncertainty will be captured using probability factors. Risks include the probability project outputs will not perform as expected or adoption will not be as high as forecast
- Economic payoff as measured by program costs (including implementation costs) and industry benefits over a 30-year period. Ratios and returns will be estimated for each project with real costs and benefits expressed in 2012 dollar terms.

Approach: The general approach will be to identify and describe objectives, outputs and outcomes from all selected projects. Economic benefits associated with outcomes will be identified and described. Sensitivity analyses will be conducted to assess the robustness of key assumptions. The consultancy will be undertaken in four distinct phases.

1. Forest & Wood Products Australia will notify relevant project researchers about the study and phone interviews will be conducted by the consultant to determine project outcomes and impacts. Existing information on industry value chains will be accessed and used to estimate or confirm potential industry benefits. Industry benefits are likely to include items such as reduced production costs, sustained access to markets or higher price margins through quality improvements. If information on environmental and social values is readily accessible, these benefits will be quantified in monetary terms.

2. A cost-benefit analysis framework will be developed and each project will be analyzed within this framework. The framework will include the project costs, objectives, outputs and expected outcomes. Investment criteria to be estimated will include Net Present Value, Benefit-Cost Ratio and Internal Rate of Return. Sensitivity analyses will be carried out for the most important assumptions.

3. Preliminary analyses will be distributed to appropriate Forest & Wood Products Australia staff and also discussed with principal researchers. Contact will be via e-mail or phone / fax.

4. Preparation of a stand-alone report that includes cost-benefit analyses and covering summary sheet. The document will also include an attachment that outlines the evaluation method used and general assumptions (such as discount rate).