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Cost-Benefit Analysis of Three Selected FWPA Projects

On board computers, formaldehyde testing of wood panels and vineyard post treatment - April 2013

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Cost-Benefit Analysis of Three Selected FWPA Projects: On board computers, formaldehyde testing of wood panels and vineyard post treatment - April 2013

Prepared for

Forest & Wood Products Australia

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EVALUATION SUMMARY

What we did?

Forest and Wood Products Australia (FWPA) systematically evaluates research and development investment following the economic analysis approach developed by the Council of Rural Research and Development Corporations Chairs (CRRDCC) in 2007. As part of this approach, random projects are drawn from populations of sub-programs and assessed to estimate the overall returns of the portfolio, or hero projects selected to demonstrate major achievements.

The evaluation framework is based on cost benefit analysis methods using cost and benefit projections over standardized time frames, discount rates, incorporation of a counterfactual (without research) scenario and explicit statement of risk. Productivity, environmental and social benefits are detailed for the levy paying industry, along with spillovers to other industries, consumers and overseas.

eSYS Development was engaged to undertake the evaluation of three randomly selected projects involving the development of a selection and implementation guide for the use of onboard computer systems for Australian forest operations, five-year inspection of preservative treated vineyard posts; and measurement of formaldehyde and other emissions from wood panels using the 1m3 chamber and desiccator test method.

How we did it?

Three investment criteria, being Net Present Value (NPV), Benefit Cost Ratio (BCR) and the Internal Rate of Return (IRR) 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 2 is estimated, then the project is estimated to deliver $2 of benefit for each dollar of project cost. The IRR is the discount rate that generates a project NPV of zero. Investment criteria, along with a description of project outputs and benefits underpinning these estimates are provided in each of the three case studies. The studies commence with an overview of objectives, then benefits and costs are quantified. Each case study is concluded with a sensitivity analysis of investment results to changes in key assumptions.

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 (2013 dollars).

Table 1: Categories of Benefits from Selected Projects

	Onboard systems for Australian forest operations		Five-year inspection of preservative treated vineyard posts		Measurement of formaldehyde and other emissions from wood panels	
Benefit	**Levy paying industry**	**Spillover** [1]	**Levy paying industry**	**Spillover**	**Levy paying industry**	**Spillover**
Economic	Increased profitability from decreased average operating costs and increased revenue per stump		Increased revenue from sale of thinning for use as posts in vineyards, as opposed to pulp and firewood	Decreased costs of vineyard post replacement due to increased strength of hardwood	Sustained access to USA market and continued profitable sales resulting from CARB accreditation	
Environment						
Social						
Total Present Value of Benefits (PVB) $million	9.27	-	0.03	0.08	0.95	
Total Present Value of Costs (PVC) $million	1.05		0.06		0.62	
Total Net Present Value (NPV) $million	8.22		0.05		0.33	
Benefit : Cost Ratio	8.84:1		1.78:1		1.53:1	

The major category of benefits delivered by the randomly selected project has been economic benefits captured by the levy paying industry. Most economic benefits from the three selected projects stem from increased revenue from stumpage as a result of the

[1] Spillover's account for consumer, other industry and overseas benefits

adoption of optimization software in harvesters. Benefits cover costs in the other two selected projects, although limited adoption of hardwood posts and a limited window of export into the USA particle board market following testing accreditation limit the overall scale of economic benefits for these two projects.

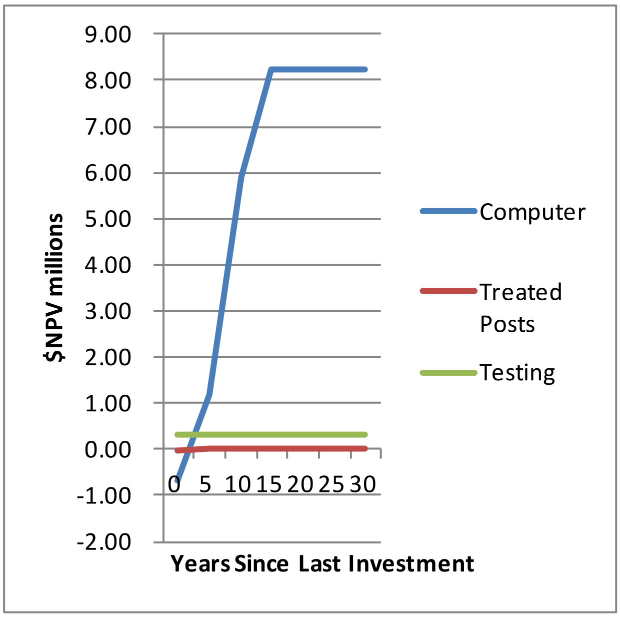

Figure 1: Projected Total NPV ($ millions)

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 computing relative to the other projects is evident in the adjoining chart. Unlike post treatment and market access benefits projects – where benefits have already covered costs – harvesting computer benefits are still largely to be generated.

DEVELOPMENT OF A SELECTION AND IMPLEMENTATION GUIDE FOR THE USE OF ONBOARD SYSTEMS FOR AUSTRALIAN FOREST OPERATIONS [2]

Background

Onboard computers have been widely adopted in the Northern Hemisphere where they generate considerable cost and productivity benefits for industry. Benefits stem from improvements in machinery utilisation, savings in fuel costs, reduced maintenance and enhanced machinery safety (CRC Forestry, 2010).

In contrast, onboard computers have had limited adoption in Australia. Pockets of adoption include use of optimisation systems for softwood harvesting operations in southern plantation areas. Limited access to information about available systems and appropriate configurations, along with minimal experience of exposure to usage of onboard technologies across the diversity of Australian forestry production systems has hindered widespread adoption.

With increasing cost pressures, complexity of management and growing capital intensity in the industry; there has been heightened demand for increased use of approaches and tools to increase productivity and value of forest and plantation production. Pursuing research and extension into the potential uses of onboard computers was an avenue for meeting this demand.

Prior to 2008 there had been limited small-scale trialling and piloting of various onboard systems, and limited information available for industry to guide decisions about appropriate onboard computing systems.

Project Objectives

The objective of this FWPA project was to promote the effective operational use of onboard computer technology in Australia through trials of different systems, development of guidelines and extension of results across a series of workshops. Specific objectives included:

- Explore the existing range of equipment and implementation methods for forest equipment tracking and management;
- Identify those best suited to the Australian context through consultation with Australian forest industry stake holders;
- Conduct trial implementations with three collaborating industry partners and draw information from existing installation in the Australian forest industry;
- Adapt data management and reporting software, combine appropriate data collection tools to address unique data needs and define and Australian specific implementation strategy based on industry stakeholder feedback and trial results; and

[2] PNC119-0809- Development of a selection and implementation guide for the use of onboard systems for Australian forest operations

- Develop and deliver to industry a machine tracking and management system selection guide, an implementation guide and basic supplemental data analysis spreadsheets/software for unique Australian needs

Project Costs

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
2008/2009	95,305	102,163	197,468
2009/2010	124,796	133,774	258,570
2010/2011	127,899	137,101	265,000
Total	**348,000**	**373,038**	**721,038**

Source: FWPA Proposal.

Project Description

The project entailed two components. The first encompassed trialling of different onboard computer systems across a range of harvesting conditions. Secondly, a guide was compiled outlining lessons from the trials as a series of case studies and providing information about various systems for potential users. Development of the guidelines was also accompanied by a series of workshops to extend results to industry.

Trial sites were selected to cover key forest types, harvesting operations and types of onboard computers. They were undertaken over a period of eighteen months in the Central Highlands of Victoria, Albany in Western Australia and Mt Gambier, South Australia. The Victorian sites involved eucalypt forest – comprising Mountain Ash (*Eucalyptus regnans*) and Alpine Ash (*E. delegatensis*). A harvester, grapple skidder and two excavators harvesting operation was fitted with GPS-enabled MultiDAT onboard computers.

The second site in South Australia consisted of a Radiata pine (*P. radiata*) plantation harvesting using a single-grip harvester, two to three forwarders and an excavator. A GPS was added to the already installed Dasa 4 system. The third site involved two feller-bunchers, five grapple skidders, and three in-field chippers harvesting Blue gum (*E. globulus*) plantation. RouteHawk onboard computers were installed in a feller-buncher, skidder and chipper and a MultiDAT system on the in-field chippers. In addition to these sites two additional trial sites were established in Canada and Gippsland, Victoria, using FPDat onboard systems.

During the first six month of the trial systems were modified and tracked to help with data collection. Following refinement of the systems a formal six months of tracking and data collection was conducted. This phase was designed to simulate standard industry operations with onboard technology. Data was compiled and categorized to allow identification of data types and level of information management complexity for different systems.

The results of these trials formed the basis of the content for the "Enhancing forest machine efficiency: Onboard computer selection and implementation guide". In addition to the guide a series of six half-day workshops were held across southern Australia (Launceston, Albany, Bunbury, Mt Gambier, Traralgon and Tumut) to transfer experience from the trials to potential adopters of onboard computing. In total - 93 people attended - with attendees receiving a printed copy of the guide at the workshop.

Outputs

The project has led to an increase in the knowledge base about onboard computing in Australia and resulted in the development of guidelines which have been disseminated to industry. Trials at each of the sites generated key lessons for computer operation, along with helping in identifying major costs and economic benefits for potential users of the technology.

In the case of the first trial in Victoria, results from MultiDATs highlighted underutilisation of the harvester and skidder due to constraints at log landing. Log loading was modified to improve work and timber flow, although an increase in haulage capacity was required to improve overall harvesting operation productivity. GPS results identified the need for more accurate supply maps. Use of the system required considerable calculation which may preclude widespread adoption.

Operational issues in relation to GPS use on Dasa systems, along with complication associated with forwarder use in the second trial underlined the complexity of retrofitting. The system is now being restricted to machine manufacturers. The third trial illustrated that RouteHawk onboard computers are not suitable for harvest operations due to vibration, and are most useful for trucks.

Results of the MultiDATs in chippers provided useful utilisation data. Multidats identified that the long-term utilisation of the chippers was significantly lower than previously thought, with major reasons including chipper breakdowns and time spent waiting for trucks. Based on these results a follow-up project was started by the Australian Forest Operations Research Alliance to improve communications and coordination between chippers and the trucks.

The use of the FPDat system to collect roadside stock information in the additional trials showed the potential for this technology to provide timely information to truck dispatchers. These lessons and solutions were included in the guidelines. Each system was outlined in terms of available units, implementation information, successful use benefits and a brief statement of economic net returns from adoption (CRC Forestry, 2010).

Benefits

The guide and trials have increased awareness of onboard systems and their potential benefits in Australian conditions. More Australian forest owners and harvesting operators are investing in this technology and further research is being conducted to explore broader avenues for utilisation of this technology. An example is the onboard optimisation research conducted by the CRC Forestry, which ran in parallel to the last two years of this project.

An additional site was established in NSW to investigate optimisation benefits. It involved two 100-tree plots in a pine plantation. Trees on the first plot were harvested according to normal operations without optimisation, while the trees on the second plot were harvested using optimisation (TimberMatic/TimberRite) Harvester productivity was found to be far greater in the optimised harvesting plot (Walsh, 2012).

Most harvesters are fitted with manufacturer onboard systems that record log and stem dimensions as each tree is harvested. Softwood harvesting operations in Victoria have being using the software for nearly 10 years. The use of optimisation in NSW, Western Australia and South Australian pine forests was limited as operators often need to manually transfer data and manage data generated by onboard computers.

Regular calibration of length and diameter measurements is also required to sustain the benefits of using the technology. These constraints, along with resistance by some harvesting operators to adopt emerging technology have retarded adoption in many areas. Awareness and experience generated by the trials have encouraged pine forest harvesters and owners outside of Victoria to adoption optimisation computing.

The adoption and effective implementation of optimisation systems will help improve productivity of forestry equipment, along with increasing the value of harvested product through enhanced cutting instructions. These benefits are quantified in the subsequent section.

Measurement of Costs and Benefits

Benefits

Optimisers which have been programmed with optimal cutting instructions will harvest the economically most attractive product combination from each harvested stem.

A comparison of value recovery between the control and that obtained using optimisation in NSW pine forests had a significant positive impact on the value of harvest.

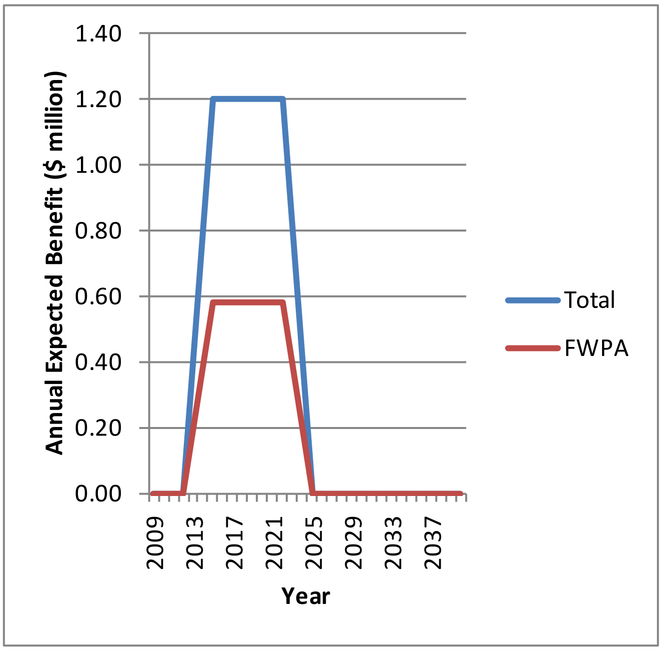

Figure 2: Annual Benefit Cash Flow

The improvement was estimated to be $0.99 per m3 harvested (Walsh, 2012). Productivity benefits were also realised through improved harvester work flow. A 9.3% improvement in the harvester's productivity reduced harvesting and extraction costs by $0.55/m3 (Walsh, 2012). There are some costs associated with adoption, despite software already being installed on new machines. For example, data is generally downloaded using USB memory, data entry is required to log the onboard computer and cutting instruction files need to be updated. To accommodate these costs it is assumed a $0.3/m3 productivity benefits could be realised. A conservative optimisation benefit for increased value of stumpage revenue of $0.5 per m3 is also included to account for different forest conditions.

Potential Adoption

Australia's coniferous and broadleaved plantation estate increased slightly in 2011 to a total of 2 017 000 hectares, compared with 2 009 000 hectares in 2010 (ABARE, 2012). Total coniferous forest area was around 1 million hectares in the corresponding time period. Pine plantations in NSW, Western Australia and South Australia are assumed to be the major potential adopting areas of optimisation resulting from the research due to interest of forest owners in these areas. The coniferous plantation estate in these areas is estimated to be about half of the national total.

Table 3: Major coniferous species, by region, 2006–11

Year	**2005–06**	**2006–07**	**2007–08**	**2008–09**	**2009–10**	**2010–11**
State	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha
New South Wales	280.0	285.7	285.6	287.8	295.5	295.8
Victoria	218.9	219.4	219.9	220.0	226.4	225.9
Queensland	187.7	188.8	189.2	190.7	188.3	189.1
South Australia	124.2	122.9	122.9	123.4	128.4	128.5
Western Australia	105.1	106.7	109.2	110.9	100.2	100.2
Tasmania	73.6	75.0	77.0	77.1	74.7	75.1
Northern Territory	2.2	2.2	2.2	2.2	2.4	2.4
Aust. Capital Territory	9.5	9.5	7.9	7.9	7.7	7.7
Australia	**1 001.1**	**1 010.2**	**1 013.8**	**1 020.1**	**1 024.0**	**1 024.8**

Source: ABARE (2012)

The volume of harvested coniferous logs has increased from 14.4 million m3 in 2006 to 15.0 million m3 in 2011 (ABARE, 2012). Western Australia, NSW and South Australia account for around half of this volume. The volume of coniferous production is not forecast to substantially increase (Parsons *et al*. 2007). Projections provided by ABARE account for establishment and growth rate of each plantation type and estimate the observed coniferous production of 15.5 million in 2005/09 will increase to 15.9 million m3 by 2015/19. For cost-benefit projections it is assumed that the volume will remain constant at 15 million m3 and that most (75%) of the 8 million m3 of coniferous logs produced from forests in Western Australia, NSW and South Australia would be harvested using optimisation systems.

Table 4: National Coniferous Logs Harvested, 2004–11

Year	**2005–06**	**2006–07**	**2007–08**	**2008–09**	**2009–10**	**2010–11**
Volume	'000 m^3	'000 m^3	'000 m^3	'000 m^3	'000 m^3	'000 m^3
Total	**14 379**	**14 590**	**15 157**	**13 314**	**14 433**	**15 041**

Source: ABARE (2012

Not all the benefit from adoption can be attributed to the FWPA project. Development of the guidelines and trials of other systems is assumed to encourage interest in Australia for research and adoption relating to onboard systems. Many new harvesters have on-board systems already installed, and the research and development project has helped to encourage wider usage. Correspondingly, only 25% of benefits are attributed to the FWPA-supported project. In addition to attribution, the costs of the follow-on CRC supported optimisation costs need to be included in the cost-benefit analysis. These were estimated to be $121 thousand.

Counterfactual.

As software is already included in harvesters it is likely that the technology would have been widely adopted across industry through private industry at some point in the future. Correspondingly, it is assumed the project has accelerated the widespread adoption of on-board systems by 10 years. A summary of the assumptions is provided in Table 5.

Table 5: Summary of Assumptions

Item	Assumption	Source
Harvester Cost Savings from On-board Computer Optimisation	\$0.30/m3	Walsh (2012) found a cost saving of \$0.55/m3
Value Benefit from On-board Computer Optimisation	\$0.50/m3	Walsh (2012) Quantifying the value recovery improvement using a harvester optimiser found an increase in the value of logs harvested of ~\$1.00/m3 in NSW trials.
Volume of coniferous logs in NSW, WA and SA	8 million m3	ABARE (2012)
Maximum adoption of on-board computer optimisation	75%	Consultant estimate based on most harvesters in softwood of forests adopting systems
Rate of Adoption	25% per year	Estimate derived from assumption maximum adoption achieved in three years
Attribution	25%	Consultants estimated that 25% of benefit can be attributed to this investment
Year Adopted	2013	Year widespread adoption from project established
Additional funding	\$121 thousand	CRC optimisation research program
Counterfactual	10 year lead time	Consultant estimate assuming software would have been adopted 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 present value of benefit of \$9.27 million was estimated over a 30 year projection. The present value of costs was estimated to be \$1.05 million, when CRC costs are also included. The net present value was calculated to be \$8.22 million.

Table 6: Results of Cost-Benefit Analysis for Total Investment at 5% Discount Rate.

Investment criteria	**Period of Benefit (in Years from Last Investment in 2007/08)**					
	0	**5**	**10**	**15**	**20**	**30**
Present Value of Benefits ($m)	0.00	2.25	6.96	9.27	9.27	9.27
Present Value of Costs ($m)	0.67	1.05	1.05	1.05	1.05	1.05
Net Present Value ($m)	-0.67	1.20	5.91	8.22	8.22	8.22
Benefit–Cost Ratio	0.00	2.14	6.63	8.84	8.84	8.84
Internal Rate of Return (%)	nc	25.90%	43.4%	44.70%	44.70%	44.70%

The results of the FWPA cost-benefit analysis are reported in Table 7. It was estimated that the NPV of the project from FWPA's investment is $3.89 million after 30 years. FWPA benefits were scaled in proportion to the allocation of FWPA's contribution to total project costs.

Table 7: Results of Cost-Benefit Analysis for FWPA Investment at 5% Discount Rate.

Investment criteria	**Period of Benefit (in Years from Last Investment in 2007/08)**					
	0	**5**	**10**	**15**	**20**	**30**
Present Value of Benefits ($m)	0.00	1.09	3.36	4.48	4.48	4.48
Present Value of Costs ($m)	0.36	0.58	0.58	0.58	0.58	0.58
Net Present Value ($m)	-0.36	0.50	2.78	3.89	3.89	3.89
Benefit–Cost Ratio	0.00	1.87	5.78	7.69	7.69	7.69
Internal Rate of Return (%)	nc	22.05%	40.3%	41.71%	41.71%	41.71%

Sensitivity Analysis

The impact on investment returns resulting from changes in attribution (Table 8) and net benefit from enhanced stumpage value (Table 9) are reported in the following tables. It is evident that the net present value of the project increases by nearly $4.48 million in the event that 50% of the benefits from adoption of optimisation systems could be attributed to this project.

Table 8: Sensitivity of FWPA Investment
Criteria to Attribution

Investment Criteria	**10%**	**25 % (Base)**	**50%**
PV of Benefits ($m)	1.79	4.48	8.95
PV of Costs ($m)	0.58	0.58	0.58
Net Present Value ($m)	1.21	3.89	8.37
Benefit Cost Ratio	3.08	7.69	15.39
Internal Rate of Return (%)	22.47%	41.71%	60.39%

It is evident that the net present value of the project is sensitive to the net benefit from enhanced product value from cutting instructions. NPV increases by $2.8 million if the net benefit was $1 per m3.

Table 9: Sensitivity of FWPA Investment
Criteria to the Benefit Received from Added Value Benefit

Investment Criteria	$0.25 per m3	$0.5 per m3 (Base)	$1 per m3
PV of Benefits ($m)	3.08	4.48	7.27
PV of Costs ($m)	0.58	0.58	0.58
Net Present Value ($m)	2.50	3.89	6.69
Benefit Cost Ratio	5.29	7.69	12.50
Internal Rate of Return (%)	33.18%	41.71%	54.36%

Conclusion

The trials conducted in the project and guidelines developed using trial lessons have increased awareness and the scope for the adoption of onboard systems. The use of optimisation software as a result of this awareness has the potential to generate considerable economic benefits. Even a small attribution of industry benefits back to this research results in considerable economic returns. Further extension to industry through forest industry trade publications, continuing investigation into uses of computers and supporting adopters would further enhance the economic attractiveness of this investment.

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Damian Walsh – University of the Sunshine Coast

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FIVE-YEAR INSPECTION OF PRESERVATIVE TREATED VINEYARD POSTS [3]

Background

Establishment costs are a major expenditure item for vineyard production. Of these costs, the expenditure associated with installation of trellises is the most substantial. Somewhere in the order of 500-800 natural rounds (or posts) are used per hectare as in-line posts, with three quarters of those in Australia being treated *Pinus* species and to a lesser extent steel or untreated timbers.

During the 1990s there was rapid expansion in the grape bearing area across Australia and commonly used pine posts of a 75-100 mm diameter became in short supply. In addition to post demand for growing area expansion, posts are also required to replace those damaged during harvesting in established vineyards. This replacement has been estimated to be as high as 15%.

Eucalypt plantation thinnings are an alternative timber supply for vineyard trellis development. Use in vineyards represents a higher value market for this by-product, although young eucalypts need to be treated with preservatives before they are suitable for this application.

An earlier FWPA research project investigated the use of young hardwood species for vineyards. Most of the timber was air dried under several regimes, however, the research also explored optimal microwave conditioning of *Eucalyptus grandis* and *E. globules.*, There were two preservative treatments for hardwood and softwood species.

The research demonstrated that eucalypt posts have advantages over softwood posts related to enhanced strength. The longer term performance of softwood and hardwood trellis's required investigation – particularly in relation to serviceability and breakage, splitting, nail holding capability, bio-deterioration and surface quality.

Project Objectives

The key objective of the project was to undertake a five-year inspection of the performance of preservative treated vineyard posts in north-west Victoria and Griffith in southern New South Wales. The relatively low cost project aimed to follow-up on the results of the previous FWPA vineyard post project in which a wide variety of timber species and preservative retentions were installed for comparison as vineyard posts.

[3] PNB049-0809 - Five-year inspection of preservative treated vineyard posts

Project Costs

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
2008/2009	15,000	31,500	46,500
Total	15,000	31,500	46,500

Source: FWPA Proposal.

Project Description

The established trial consisted of grapevine trellises constructed from 1460 treated posts, consisting of 520 pigment emulsified creosote (PEC), 810 alkaline copper quaternary compound (ACQ), 70 creosote and oil mix, and 60 copper chromium arsenic (CCA) at Seppelt's vineyards in Victoria and McWilliams at Griffith in New South Wales (McCarthy et al. 2005).

The Victorian site receives an average annual rainfall of 530 mm. A total of 880 posts comprising 295 PEC, 485 ACQ, 70 creosote and oil mix and 30 CCA were installed. The average annual rainfall at the NSW site in Griffith is 410 mm and irrigation is used. Trellises were constructed from 580 posts, consisting of 225 PEC, 325 ACQ and 30 CCA-treated posts.

Following the key objective of the project, the major activity was inspection of the above ground condition of installed posts for serviceability, breakage, nail holding and splitting. Posts were examined for preservative cleanliness and splits using the Auspine Work Procedures Manual. A random selection of 10 posts of each treatment was subject to ground-line assessment for bio-deterioration. The posts were given a performance rating of 8-0 based on the amount of cross-section lost.

Outputs

Research has increased the body of knowledge about vineyard post treatment and optimal species usage. Results were included in a final report and peer reviewed publications outlining treatment results and inspection methods. Presentations were also made at agro-forestry forums. Key research results related to decay, splitting and breakage were outlined in the publications.

Results include that all PEC-treated posts were sound and no bio-deterioration was seen on any post, which was expected given concentrations of treatment for most species were well above industry standards. Most hardwood posts treated with ACQ had decay. ACQ-treated *A. mearnsii* posts were the poorest performing in terms of decay. This species along with *E. cladocalyx* and *C. maculata,* were the least absorbent of preservatives amongst the hardwood species included in the trial.

None of the analysed posts met the minimum treatment requirement for retention. *E. grandis* and *E. globulus* posts had the best mean retentions, but were still subject to fungal decay. Around 45 of 491 posts treated with PEC had bleeding of exudate. *C. maculata* had the most observed degree of bleeding, particularly from the PEC-treated posts. A total of four *A. mearnsii* and one *E. cladocalyx* creosote and oil-treated posts also demonstrated a degree of bleeding.

Around 71 of 1314 posts were broken, either during installation or as a result of harvesting. ACQ- and CCA-treated posts were the most frequently broken posts, mainly from species including *A. mearnsii, E. grandis* and *P. radiata*. No PEC-treated posts at Griffith were broken and only two creosote and oil-treated *E. globulus* posts were broken. Splitting was more predominant in ACQ-treated posts than PEC-treated posts at Griffith and Great Western, while A. mearnsii posts had the highest proportion of splitting in ACQ- and PEC-treated posts at both sites.

The Auspine Work Procedures Manual was followed to rate the impact of splitting, with posts with more than 8mm splitting being considered to have excessive defect. Around 5.9% of PEC-treated posts and 16.7% of ACQ-treated posts had excessive splitting. No splits were recorded in *E. grandis* and *E. globulus* posts treated with PEC. There was a decrease in splitting for the debark and gang nail drying regime, when compared to the debark only posts, for ACQ- and PEC-treated posts at both sites.

Benefits

The results show that several plantation species were well suited as in-service vineyard posts and were performing as well as commonly used CCA-treated *P. radiata* posts. The durability of all the PEC-treated hardwood species was confirmed with no decay present on any of the posts using this treatment. *E. cladocalyx* and *C. maculata* were the two best hardwood species in terms of strength during harvest. *E. grandis, E. globulus* and *E. pilularis* also performed well and were deemed as being satisfactory hardwood species for use as vineyard posts.

The research demonstrated that PEC treated hardwood has greater strength, and is less subject to breakage when compared to CCA-treated *P. radiata*. As such, hardwood plantation thinnings could be used as vineyard posts. The use of thinnings for higher end-use, when compared to pulp and firewood, has the potential to increase hardwood plantation profitability. In addition to the timber industry, grape producers could benefit from not having to replace as significant a proportion of trellises.

Replacement demand of as high as 15% was cited in the project documentation. Much of the damage was assumed to be caused by mechanical harvesters. Based on a growing area of around 158 thousand hectares and 500-800 posts per hectare, replacement of this order equates to 14.2 million posts per annum.

Measurement of Costs and Benefits

Potential Adoption

Establishing vineyards are the key target for adoption of hardwoods for trellis development. During the 1990s there was expansion in the area grown to grapes. Since that time expansion has declined. ABARE estimated that wine grape production in 2010–11 was 1.56 million tonnes, or 2 per cent more than the 2010 harvest. (Gunning-Trant and Shafron, 2012, ABS, 2011). The growth in demand for Australian wine has slowed considerably, as competition in export markets has increased. This has placed downward pressure on grape prices and on growth in the production area. This decrease is evident in the national production areas between 2008 and 2012 outlined in Table 2. It is apparent that the area decreased from 166 thousand hectares in 2008 to 145 thousand hectares in 2012.

Table 2: Area Planted to Vineyards. 2008-2014

	2008	**2009**	**2010**	**2011**	**2012**	**2013[f]**	**2014[f]**
Area '000 hectares	166	157	152	154	145	158	158

Source: Gunning-Trant and Shafron, (2012), ABARE (2012)

Given the demand outlook appears to be flat; the scope for increases in growing area in the medium term is limited. The benefits of the project are therefore assumed to be generated on areas planted to vineyards prior to 2013. Much of the use of hardwood trellis materials stemmed from collaboration with selected timber producers in southern Australia not long after the project was completed.

For example, Koppers explored the use of hardwood posts at this time, although market demand diminished after a few years. Grower preference for softwood posts constrained adoption, along with problems associated with checking in hardwood posts. In this period it was estimated that 10,000 posts per year were sold to vineyards from 2010-2012. Given that around 600 posts are established per hectare, this amounts to 17 hectares per year, or a cumulative total of around 50 hectares.

Since 2012 it is not clear that any millers are supplying hardwood for grape trellis material. The trellis posts most commonly used in Australian vineyards are pine posts treated with the chemical preservatives creosote or copper-chromium-arsenate (CCA).

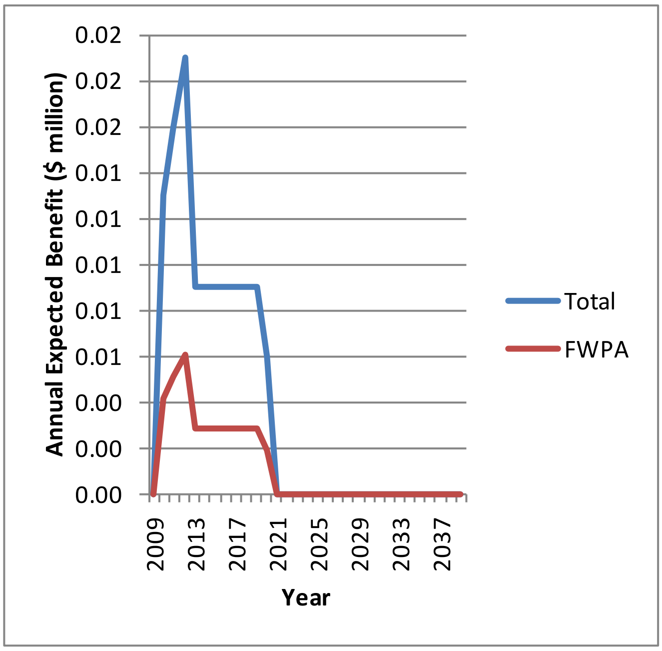

Figure 1: Annual Benefit Cash Flow

Adopting Plantation Benefits

Hardwood plantation owners and vineyard producers are estimated to benefit from the use of hardwood trellises. Plantation owners benefit from having a higher value use for thinnings. This is assumed equivalent to be $2 per post, although there is no clear evidence of price premium over alternate uses such as pulp or firewood. Vineyard owners are estimated to gain benefits from not having to replace as many posts per year, over a 10 year period.

Typically 500-800 posts per hectare of the preferred size are used as in-line posts for new and redevelopment vineyards. It is estimated that the use of hardwood posts reduces the need for replacement by 2%. Given the cost of replacing a broken post within an established vineyard can range from $30 to $100 each, an annual benefit of $360 per hectare is estimated for vineyard owners. The five year trial served to re-enforce knowledge about hardwood durability. As such, 50% of estimated benefits are attributed back to the research project.

Counterfactual.

The situation in the absence of the five year trial needs to be considered. This scenario is often referred to as the counterfactual and involves an assessment of the likelihood of the research being carried out by other organisations if FWPA had not funded the project. Given the timber producers associated with the project only supplied the market for 3 years, the benefits of the research are already truncated, and the likelihood of alternate millers supplying the market is limited. A summary of the assumptions is provided in Table 3.

Table 3: Summary of Assumptions

Item	Assumption	Source
Hardwood Vineyard Posts	10,000 per year	Consultant estimate derived from industry discussions
Years of Hardwood post production	2010-2012	Consultant estimate derived from industry discussions
Net Benefit to Hardwood producers	$2 per post	Estimate derived from pole cost of $6, and assumes alternate use of thinning for firewood attracts a lower price of around $2 less
Hectares of Vineyard adopting hardwood	17 hectares per year for 3 years	Derived from pole density of 600 per hectare. (Mollah *et al* 2006)
Cost saving per year	$360 per hectare	Assumes 2% less replacement using hardwood, and cost of replacement $30 per post (Mollah 2007)
Vineyard life	10 years	Assumes trellis has a working life of 10 years.
Attribution	50%	50% of benefit can be attributed to this investment due to other research in the field

Results

The period of analysis was for 30 years after the last year of project investment. The results are expressed in 2012-13 dollar terms and all benefits and costs are discounted to 2012-13. The results for the cost-benefit analysis are reported in Table 4. It is evident that the total investment yields a positive economic benefit 30 years after the last year of project expenditure. In total, a net present value of $0.05 million is estimated over a 30 year projection.

Table 4: 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**	**30**
Present Value of Benefits ($m)	0.00	0.07	0.11	0.11	0.11	0.11
Present Value of Costs ($m)	0.06	0.06	0.06	0.06	0.06	0.06
Net Present Value ($m)	-0.06	0.01	0.04	0.05	0.05	0.05
Benefit–Cost Ratio	0.00	1.12	1.71	1.78	1.78	1.78
Internal Rate of Return (%)	nc	13.31%	20.63%	20.63%	20.63%	20.63%

Following ACIL-Tasmans' Economic Evaluation Guidelines, the investment is assessed from the perspective of FWPA investment. Total benefits attributed to FWPA are scaled on the basis of FWPAs contribution to total project costs. The results of the FWPA cost-benefit analysis are reported in Table 5. It is estimated that the NPV of the project from FWPA's investment is $0.02 million after 30 years.

Table 5: 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**	**30**
Present Value of Benefits ($m)	0.00	0.02	0.03	0.04	0.04	0.04
Present Value of Costs ($m)	0.02	0.02	0.02	0.02	0.02	0.02
Net Present Value ($m)	-0.02	0.00	0.01	0.02	0.02	0.02
Benefit–Cost Ratio	0.00	1.12	1.71	1.78	1.78	1.78
Internal Rate of Return (%)	nc	13.31%	20.63%	20.63%	20.63%	20.63%

Sensitivity Analysis

There is a substantial amount of uncertainty surrounding a number of variables used in the baseline evaluation. The impact on investment returns resulting from changes in attribution (Table 6) and net benefit from vineyard trellis replacement cost savings (Table 7) are reported in the following tables. It is evident that the net present value of the project increases by nearly $0.03 million in the event that 75% of the benefits could be attributed to this project.

Table 6: Sensitivity of FWPA Investment
Criteria to Attribution

Investment Criteria	**25%**	**50 % (Base)**	**75%**
PV of Benefits ($m)	0.02	0.04	0.07
PV of Costs ($m)	0.02	0.02	0.02
Net Present Value ($m)	0.00	0.02	0.05
Benefit Cost Ratio	0.89	1.78	3.56
Internal Rate of Return (%)	2.53%	20.63%	51.66%

It is evident that the net present value of the project is sensitive to the net benefit from pole replacement cost savings. Hardwood trellis replacement needs to be at least 1% less than softwoods for the project to breakeven

Table 7: Sensitivity of FWPA Investment
Criteria to the Benefit Received per Hectare from Replacement Cost Savings

Investment Criteria	1% pole replacement	2% replacement (Base)	5% pole replacement
PV of Benefits ($m)	0.02	0.04	0.07
PV of Costs ($m)	0.02	0.02	0.02
Net Present Value ($m)	0.00	0.02	0.05
Benefit Cost Ratio	1.16	1.78	3.66
Internal Rate of Return (%)	8.90%	20.63%	43.68%

Conclusion

The supply of hardwood to vineyards following this project was small scale, as only limited industry participation was evident in this market. Problems associated with consumer acceptance of hardwood posts, securing supply and product checking hindered the longer term use of the identified species and also project benefits. Given the project budget was relatively small, even an adoption period of three years has generated a positive benefit for the project. The rationale for discontinuation of supply needs to be further investigated.

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MEASUREMENT OF FORMALDEHYDE AND OTHER VOC EMISSIONS FROM WOOD PANELS USING THE 1M³ CHAMBER AND DESICCATOR TEST METHODS [4]

Background

Formaldehyde is incorporated as an additive in products such as Medium Density Fibreboard (MDF) and Particleboard. Since the International Agency for Research on Cancer classified formaldehyde as being carcinogenic to humans; there has been increasing scrutiny on the products use. Industry has responded to these concerns through the development of panels with extremely low formaldehyde emissions.

Leading markets for Australian panels, such as California, instituted regulations which restricted the import of panels that exceeded formaldehyde emission thresholds. To maintain market access from early 2009 it was necessary to gain testing certification by the Californian Air Resources Board (CARB) that panels did not exceed emission limits.

Emission certification was principally attained using the Chamber Test Method as the reference method for Global Panel Standards. The Desiccator Test Method was the key test being used in Australia, therefore, correlations needed to be developed in order for certification to be attained.

Research in this field was considered vital so that the Australian industry could conform to the ISO Global Standard in both domestic and export markets. The procedure for each test was complex and required significant resources.

Project Objectives

To measure Formaldehyde and VOC emissions from wood panels produced by Australian Panel Manufacturers to determine statistically valid correlations between the ISO $1m^3$ Chamber reference test and the Desiccator test method in use in Australia.

[4] PNB035-0506 - Measurement of Formaldehyde and other VOC emissions from Wood Panels using the $1m^3$ Chamber and Desiccator Test Methods

Project Costs

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
2005	101,135	111,030	212,165
2006	32,275	24,705	56,980
2007	7,270	10,832	18,102
2008	9,320	17,433	26,753
2009	10,000	10,000	20,000
2010	18,000	18,000	36,000
Total	**178,000**	**192,000**	**370,000**

Source: FWPA Proposal.

Project Description

The first part of the research program was to certify the AWPA Test Centre (ATCA) so members could routinely test panels using the desiccator method for compliance with emission standards. Application documentation and procedures for the test centre to be accredited by CARB were undertaken in June 2008. Approval from CARB for ATCA to be an accredited third party certifier was obtained in late 2008.

The second part of the research involved establishment of chamber test capacity in Australia. A 1m3 small chamber commenced trial operation in August 2008 and continued until April 2010. Research into calibrating chamber tests in Australia and dessicator formaldehyde test methods was undertaken. Correlations required 32 points for validation, therefore, 32 tests were conducted using $1m^3$ chamber and desiccator methods. Correlations with ATCAs JIS A 1460 desiccators test as well as Advanced Testing Service (Oregon) and Asure Quality (NZ) large chambers were investigated. Obtaining sound correlations between the results of the ATCA small chambers and large chambers was very problematic.

In order to get CARB approval for both these chambers it was necessary to demonstrate strong correlation with the CARB reference test which employs a large 1064 ft3 chamber that tests full size panels. The R^2 between the large and small test needs to be > 0.7. This was not achieved. R^2s of between 0.1 and 0.5 were generated from the testing. Changes in the sealing of the chambers, modification to the airflow metering and improvements to the control of temperature and humidity of the chambers were implemented to try and improve correlations. These modifications helped to improve the strength of R^2, however, not up to the CARB standard.

Consultants were engaged in early 2010 to overcome the correlation problem. The chamber correlations were re-examined and it was concluded that the chambers were still overly leaky and required sealing, the laminar flow airflow measuring equipment was unable to be calibrated on site, the air pump required re-plumbing and the temperature and humidity control of the conditioning room were inadequate. The cost to rectify the conditioning room, alone, was estimated to $120,000. Consequently, obtaining equivalence of small chamber tests with large chamber tests was not achieved.

Obtaining equivalence of the small chambers with large chambers is not required for accreditation as a third party tester. Approval of equivalence by CARB would have enabled ATCA to conduct testing in-house, rather than subcontracting this testing to another CARB accredited tester. This would reduce cost to ATCA by approximately $15,000 per year per certified mill.

Outputs

The key output from the research was that ATCA obtained accreditation by CARB as a third party testing centre using the dessicator method. The research enhanced the body of knowledge about correlations between desiccator and chamber testing in Australia. Correlations between small and large chamber tests could not be developed to the level required by CARB. Cost considerations and uncertainty about the testing site location hampered further efforts to refine correlations.

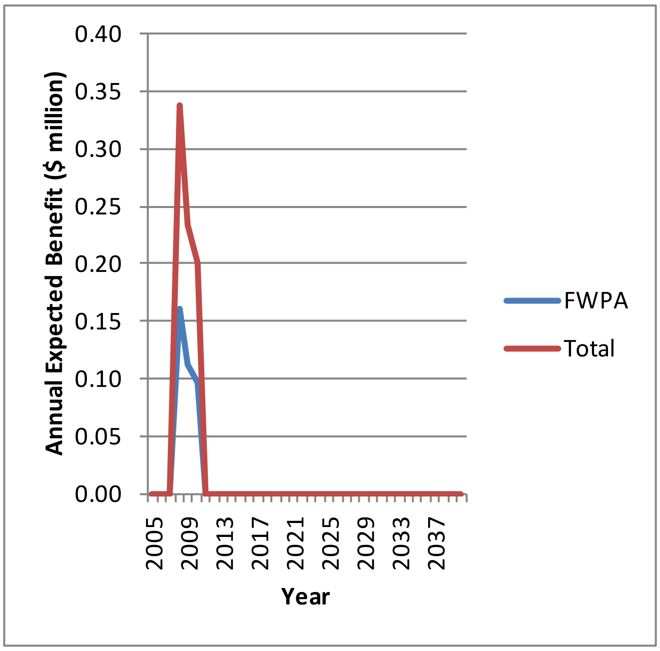

Figure 1: Annual Benefit Cash Flow

Benefits

Australian panel manufacturers benefited from being able to meet import demands from the key USA market for low formaldehyde emission panel products. The CARB regulation sets limits on allowable emissions from panels. Product that did not meet these standards, or was not tested by an accredited centre, could not be supplied into the Californian market. Australia was able to become certifier – using research on dessicator and chamber testing methods, therefore allowing continued access into this market. Substantial volumes of MDF were shipped between 2008 and 2010, generating economic benefits for the wood panel industry in Australia.

Measurement of Costs and Benefits

Potential Adoption

Between 2010 and 2012 wood product exports from Australia decreased from $2.5 billion to $2.2 billion. The value of export of wood panels in 2008 was $109 million, which fell to $83 million in 2012 (ABARE, 2012). The decrease in the volume of MDF export volumes is evident in Table 2. Around 203 thousand m3 was shipped in 2008, which declined to 79 thousand m3 by 2012. MDF accounted for $76 million in export sales in 2008, which fell to $26 million by 2012. It is difficult to ascertain the value of exports for individual suppliers. For the purposes of the evaluation it is assumed that 20% of total MDF export sales between 2008 and 2010 were facilitated by third part testing and access provided under CARB accreditation.

Table 2: Wood Product Production and Export

	Unit	**2007–08**	**2008–09**	**2009–10**	**2010–11**	**2011–12**
Total Production						
Veneer	’000 m^3	82	117	123	132	122
Plywood	’000 m^3	134	118	120	140	160
Particleboard	’000 m^3	957	911	928	986	866
Medium density fibreboard	’000 m^3	710	632	558	605	466
Total	’000 m^3	**1 882**	**1 778**	**1 730**	**1 863**	**1 614**
Export						
Veneers	’000 m3	34.8	85.7	89.8	119.0	105.6
Plywood	’000 m3	14.8	52.6	23.8	6.9	33.7
Particleboard	’000 m3	6.2	16.7	9.4	5.6	3.5
Hardboard **c**	’000 m3	0.4	1.8	1.3	2.2	1.9
Medium density fibreboard	’000 m3	203.6	181.0	129.8	114.9	79.3
Softboard and other	’000 m3	14.2	7.6	1.7	4.7	20.1
Total	**’000 m3**	**273.8**	**345.4**	**255.8**	**253.3**	**244.0**

Source: ABARE (2012)

Adopting Benefits

When ATCA was certified, there were sales of significant volumes of MDF into the Californian market estimated to be $9-15 million per year. The profit margin on this volume was in order of 3%, therefore generating annual profits of $0.3-0.5 million to Australia. Given the trade was sustained for around 2-3 years after testing, the net economic benefit of accreditation was around $1 million.

Not all the benefits of accreditation can be attributed to the project. Accreditation involved the use of sub-contracted testing in New Zealand and actions of Australian industry involved in MDF export. Correspondingly, 75% of economic benefits are assumed to be attributed to the FWPA-supported research.

Key assumptions used in the cost-benefit analysis are outlined in Table 3. It is estimated that obtaining CARB certification enabled trade into the USA for 3 years that would not have been possible without the project. Around half of the benefits of the certification are attributed to the project as ATCA was the key agency involved in the research.

Table 3: Summary of Assumptions

Item	Assumption	Source
US Wood Panel Market	$9-15 million per year	Consultant estimate based on 20% of export value of MDF between 2008-2010 (ABARE, 2012)
Profit Margin	3%	Consultant estimate based on a margin of less than 5% for wood panels.

Years of trade	2008-2010	Years between certification and cessation of USA panel trade
Attribution	75%	75% of benefit can be attributed to this investment
Year Adopted	2008-2010	Accreditation attained

Results

The period of analysis was for 30 years after the last year of project investment. The results are expressed in 2012-13 dollar terms and all benefits and costs are discounted to 2012-13. The results for the cost-benefit analysis are reported in Table 4. It is evident that the total investment yields a positive economic benefit 30 years after the last year of project expenditure. In total, a net present value of $0.33 million is estimated.

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

Investment criteria	**Period of Benefit (in Years from Last Investment in 2009/10)**					
	0	**5**	**10**	**15**	**20**	**30**
Present Value of Benefits ($m)	0.95	0.95	0.95	0.95	0.95	0.95
Present Value of Costs ($m)	0.62	0.62	0.62	0.62	0.62	0.62
Net Present Value ($m)	0.33	0.33	0.33	0.33	0.33	0.33
Benefit–Cost Ratio	1.53	1.53	1.53	1.53	1.53	1.53
Internal Rate of Return (%)	21.25%	21.25%	21.25%	21.25%	21.25%	21.25%

Total benefits attributed to FWPA are scaled on the basis of FWPAs contribution to total project costs. The results of the FWPA cost-benefit analysis are reported in Table 5. It is estimated that the NPV of the project from FWPA's investment is $0.16 million after 30 years.

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

Investment criteria	**Period of Benefit (in Years from Last Investment in 2007/08)**					
	0	**5**	**10**	**15**	**20**	**30**
Present Value of Benefits ($m)	0.45	0.45	0.45	0.45	0.45	0.45
Present Value of Costs ($m)	0.30	0.30	0.30	0.30	0.30	0.30
Net Present Value ($m)	0.16	0.16	0.16	0.16	0.16	0.16
Benefit–Cost Ratio	1.52	1.52	1.52	1.52	1.52	1.52
Internal Rate of Return (%)	21.12%	21.12%	21.12%	21.12%	21.12%	21.12%

Sensitivity Analysis

There is a substantial amount of uncertainty surrounding a number of variables used in the baseline evaluation. The impact on investment returns resulting from changes in attribution (Table 6) and profit margin from USA panel trade (Table 7) are reported in the following tables. It is evident that the net present value of the project increases by nearly $0.15 million in the event that 100% of the benefits from CARB certification could be attributed to this project.

Table 6: Sensitivity of FWPA Investment
Criteria to Attribution

Investment Criteria	50%	75% (Base)	100%
PV of Benefits ($m)	0.30	0.45	0.61
PV of Costs ($m)	0.30	0.30	0.30
Net Present Value ($m)	0.00	0.16	0.31
Benefit Cost Ratio	1.01	1.52	2.03
Internal Rate of Return (%)	5.48%	21.12%	33.04%

It is evident that the net present value of the project is sensitive to the net benefit from profit margin assumptions. A margin of more than 2% on USA exports is required for the project to breakeven

Table 7: Sensitivity of FWPA Investment
Criteria to the Profit Margin for USA Exports

Investment Criteria	1%	3% (Base)	5%
PV of Benefits ($m)	0.15	0.45	0.76
PV of Costs ($m)	0.30	0.30	0.30
Net Present Value ($m)	-0.15	0.16	0.46
Benefit Cost Ratio	0.51	1.52	2.53
Internal Rate of Return (%)	-19.99%	21.12%	42.87%

Conclusion

The project successfully achieved Australian testing accreditation from CARB using the desiccator method based on activities undertaken in the project. This allowed market access for Australian based panel exporters and generated sufficient net benefits to cover the costs of the project. Problems associated with correlations between small and large chambers prevented large chamber certification. In the event that correlations had been sufficient to achieve accreditation, project benefits would have still been curtailed by the loss of export volume benefits due to the high value of the Australian dollar.

Acknowledgments

Simon Dorries. EWPAA - General Manager
Andy McNaught. EWPAA - Technical Manager

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TERMS OF REFERENCE AND APPROACH

Task: To undertake an ex-post evaluation of three Forest & Wood Products Australia research projects. Economic analyses will be conducted for the following projects:

- Development of a selection and implementation guide for the use of onboard systems for Australian forest operations
- Five-year inspection of preservative treated vineyard posts; and
- Measurement of formaldehyde and other emissions from wood panels using the 1m3 chamber and desiccator test methods

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).