SPECIAL LIFTOUT No.91

Autumn 2010 Vol. 33 No. 1

Making ends meet: pathways to innovation in Australian forestry

By Gordon Duff, CEO CRC for Forestry

Research, development, extension and innovation have played a vital role in the growth, development and adaptation of the Australian forest and forest products sectors.

This Special Liftout identifies some past successes, present initiatives and drivers for future directions in forestry innovation, but draws attention to some concerning trends. We are witnessing a period of significant change in the way innovation occurs in forestry. Superficially, declining levels of funding support might be seen as a cause of reduced capacity and adaptability in the sector, but the more serious underlying issue may be the uncoupling of research and development from operational and strategic decision making.

In the space of a couple of decades, we have moved further away from state ownership of forest resources and closely aligned, state- sponsored research and development. The trend towards increasing private sector ownership presents additional challenges to ensure effective engagement between the people and agencies that provide research, and those that use research to innovate, adapt and grow.

Research providers and research users must make greater efforts to work together, to make best use of the research capability we have, and to ensure that the sector continues to innovate. Foresters, practitioners, and decision makers in the field have a key role to play in the innovation process. The solutions to major challenges rarely drop, gift-wrapped, into the laps of forest owners and companies. The process of innovation relies on engagement from both ends – by research provider as well as research user.

Professor Gordon Duff is the CEO of the Cooperative Research Centre for Forestry, an Australian national research consortium. The CRC for Forestry links leading Australian forest research organisations, companies, government agencies and universities in a forest science and management research and education partnership. Gordon completed a first class honours degree in botany at the University of Tasmania in 1981, and a PhD in tropical forest ecophysiology and vegetation dynamics at James Cook University in 1987.

He worked at the Northern Territory University for 10 years, lecturing in ecology, and conducting research on savanna ecology and tree physiology, and natural resources management. In 1997 he was appointed as Professor of Environmental Science at Deakin University, where he led the Deakin Initiative on Sustainability and the Environment. He was lured back to the Territory four years later, and appointed as CEO of the CRC for Tropical Savannas Management.

He took over as CEO of the CRC for Forestry at the end of 2006. Gordon is also Chairman of the Board of the Tasmanian Forest Practices Authority, Chairman of the Forest Education Foundation, and former Chair and current Board member of the Northern Territory Environment Protection Authority. He is a Fellow of the Australian Institute of Company Directors.

This article is based upon the author's personal views and is not necessarily representative of the views of any other group or individual.

Achievements of Australian forestry research

The Australian forest and wood products sector has an annual turnover of more than $21 billion (2007-08). It is an industry underpinned by a research, development and innovation system that is modest in size by international standards, but which nevertheless boasts some world-class research groups and world-leading innovations. Historically, this research, development and innovation capability has helped shaped the present day forest and wood products industry, as well as the way we manage forests for environmental and social outcomes.

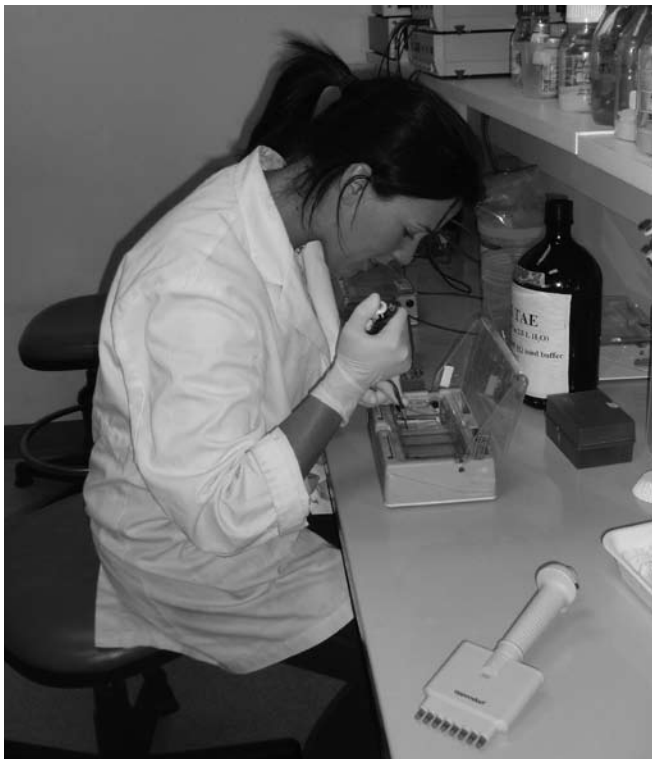
The forest and wood products sector is broader in scope than any other primary industry sector, particularly in the Australian context, even without taking re-manufacturing industries into account. The resource base includes a diversity of native forest and plantation resources, located in every Australian state and territory. Commercially, forests are managed for wood and fibre for a variety of applications, non-wood forest products (e.g. apiary), tourism and, increasingly, carbon sequestration. Non-market values such as water quality and yield, biodiversity, the management of forest fires, soil conservation and a variety of other environmental services add complexity to the goals of forest managers.

Consequently, the history and composition of forest and wood products research, development and innovation in Australia has reflected the breadth and complexity of the subject matter. Researchers who contribute to the sector represent a huge range of disciplines and specialisations. Broad-based research organisations such as the CRC for Forestry include researchers covering the range from forest engineering and logistics to sociology, and from molecular genetics to satellite-based remote sensing.

Recently, Forest and Wood Products Australia undertook the task of coordinating the production of a research development and extension (RD&E) strategy for the forest and wood products sector. The report contains a good set of examples of benefits arising from Australian investment in research and development in forestry and forest products in the last 30 years. Some highlights include:

- Advances in genetic improvement, site selection, silviculture and site resource management, which have greatly improved the productivity of softwood plantations in diverse environments, thereby ensuring continued supply to the multi-billion-dollar softwood-processing industry. Similar advances have underpinned a significant expansion of the hardwood plantation estate, from a negligible area in the early 1990s to more than a million hectares today;
- Innovations in engineered wood products have opened up new markets and created competitive opportunities, particularly for the softwood sector. Australia has been a world leader in development of laminated veneer lumber, I-beams and open-web floor joists. Advances in kiln drying and machine grading for softwoods have improved profitability and productivity;
- Forestry practices in Australia are highly regarded by international standards, through application of research in forest ecology and environmental management. Placing a high priority on biodiversity, water quality and yield has led to improvements in habitat retention and management in native forests, while maintaining economic production. Research underpins most of our contemporary approaches to managing complex forest landscapes for multiple values. The Regional Forest Agreements, that underpin the balance between production and conservation in native forests in New South Wales, Tasmania, Victoria and Western Australia, were also developed using multi-disciplinary, landscape scale approaches;
- Risk management is an important area relying on constant input from research. Research investment in biosecurity has helped ensure that potentially devastating pathogens such as guava rust and pine pitch canker have not entered Australia. Research also plays a vital role in managing significant plantation pests such as *Dothistroma*, *Sirex* and *Creiis* species;
- Forest growth and performance models are used on a regular basis to support decisions including site and species selection, silvicultural management and investment strategies. Increasingly sophisticated models, incorporating both real-world data and understanding of physiological processes, will play a major role in formulating response strategies for climate change, through both adaptation and mitigation. Model-based decision tools, such as the Bluegum Productivity Optimisation System (BPOS), are having more widespread impact as they become more accessible to users.

Recent investment in research on the breeding, silviculture and processing of plantation grown hardwoods for solid wood



PhD student Rebecca Jones: Molecular genetics research on eucalypts.

PhD student Corey Hudson: Taking leaf samples to extract DNA.

PhD student David Blackburn & FEA Innovation Manager Trevor Innes: Together with industry assessing wood quality from plantation grown Eucalyptus nitens.

products is showing real promise. The potential now exists to extract significantly increased value from future hardwood plantation rotations. For example, the latest research on solid wood products from plantation grown *Eucalyptus nitens* suggests that wood quality problems such as internal checking that bedevilled earlier studies can be addressed through a combination of genetic selection and processing, particularly reconditioning of sawn boards.

Forest harvesting and transport represent a high proportion of the total costs of delivering timber to the mill gate. A recent resurgence in research capability in this area is demonstrating that even small gains in efficiency and productivity translate to significant cost savings when multiplied up to industrial-scale, forest harvesting operations. In Australia, innovation in this sector more often results from the adaptation and application of technologies that have been developed elsewhere in the world, and tailoring them to the Australian context. Paradoxically, some exciting research on machine productivity now taking place in Australia is attracting international interest in collaboration and information sharing, particularly among other countries in the southern hemisphere.

Areas such as tree breeding, harvesting and operations, and most recently wood processing, have at times fallen from favor for research funding, and diminished or even been abandoned by major research providers. Tree breeding and forest harvesting research have been reinvigorated as needs for these capabilities have been recognised; but each time a research capability has to be rebuilt after a period of decline, there is a significant cost in terms of funding, lost investment in capability, and lost opportunity.

Application of existing technologies in novel contexts is a recurring theme in many areas of forest R&D. Airborne and ground-based LiDAR, an optical remote sensing tool initially used in applications such as meteorology, geology and astronomy, has proved enormously versatile for forest inventory and mapping. Research has focused on adapting and utilising the technology, rather than the technology itself. Similarly, forestry researchers have refined a wide variety of airborne and satellite remote sensing technologies to examine forest performance and health, at scales previously unobtainable for ground-based investigations. Perhaps surprisingly, remote sensing can provide earlier and more sensitive detection of changes in forest performance and health. Applications of hand-held, near infra-red (NIR) spectroscopy to measure cellulose content and pulp yield with a high degree of accuracy and efficiency, is yet another example of the adaptation of tools developed in other spheres to forestry applications.

The research funding environment

Government and private sector investors in RD&E regularly insist that their investment is justified. While this is a reasonable expectation, there is no completely reliable approach to quantifying the impacts of research. The question is often asked, whether for every dollar invested in research an appropriate gain can be shown in return. Sometimes the answer is straightforward, but more often there is uncertainty surrounding the pathway to adoption of research, with multiple pieces of research contributing to a single outcome. Uncertainty can also shroud the true costs of implementation, and what would have happened in the absence of the research results. Research itself has inherent risks, and outcomes are seldom 100 per cent guaranteed. Albert Einstein once said, “If we knew what we were doing, it wouldn’t be research”, and while most forest and wood products research is carefully planned, conducted and accounted for, exciting discoveries and major advances are often serendipitous. Nevertheless, methods have been developed to calculate the return on investment in research, taking account of risks and uncertainties.

One study of 25 R&D projects funded by the Forests and Wood Products Research and Development Corporation estimated the economic, social and environmental benefits from each project and compared these to the total financial investment. The study calculated the overall benefit/cost ratio for the total investment to be 11:1. A similar study carried out by the CRC for Forestry, using a conservative methodology developed by the Australian Government to evaluate the investment made in CRCs more generally, estimated a range of benefit:cost ratios for a cross section of projects from 1.8:1 to 66:1.

While such benefit:cost ratios may seem implausibly high, there are many examples of the identification and application

Anna Smith collecting foliage samples to assess the impact of fungal disease.

Wood core samples collected in the field can be assessed for cellulose content and pulp yield using portable, hand held NIR spectroscopy.

Logs are colour coded so that sawn boards can be identified during processing trials.

of relatively low-cost technological solutions that can have profound, long term impacts on productivity and hence profitability. The impact of research that contributes to the industry's social license to operate, while far harder to quantify in dollar terms, may ultimately be a significant determinant of the future of large proportions of the industry itself. Similarly, the research that identifies and effectively diminishes a significant risk, such as a devastating pest outbreak, can only be valued in dollar terms by estimating probabilities and scale of impact. Put simply, these impacts might never happen, but if they do, the effects can far outweigh any costs of research leading to prevention or mitigation. It is difficult to place a value on the research that may reduce the likelihood of a disaster.

A track record of successful innovations arising from research appears to be no guarantee of continuing support, or even acknowledgement of the importance of R&D in the future profitability and sustainability of the sector. Few would argue, however, against the need for innovation, adaptation, education and skill development if the industry is to remain competitive, embraced by society, and resilient in the face of external change.

With such a strong case to justify the investment in R&D, it seems surprising that the level of forest and wood products R&D funding has declined steadily in real terms since the 1980s. In 2007-08, Australia spent around $104 million on forest and wood products R&D; a mere 0.47% of the total value of the industry for the same period. (Note that available figures do not include extension costs, hence comparisons are based on R&D costs alone). When expenditure is adjusted to 1982 dollars, this total has declined steadily at a rate of about 0.6% per year since 1982. Furthermore, despite the size and significance of the sector to Australia, the level of investment in R&D as a proportion of the value of the industry is among the lowest of the primary industry sectors. Compared to the forest research spend of 0.47% of industry turnover, the wine sector spends twice as much on R&D relative to industry turnover (0.94%), while arguably less complex sectors such as dairy and pork invest 0.83% and 0.69% respectively.

Simply increasing the funding available for research will not solve any of our most important challenges. The declining level of investment in forest and wood products R&D may be more of a symptom than a cause, and we need to address some fundamental issues such as capacity, organisational complexity, and engagement between industry and the research community if we are to maintain a vibrant, sustainable and profitable sector.

Ongoing change in R&D capacity

Currently, it is possible to identify around 500 full time equivalent researchers, technicians and support staff involved in forest and wood products R&D. They are spread across roughly 50 state and federal government agencies, universities and private organisations. Funding sources are the Australian Government (44%), state agencies (28.5%) private sector (20% including the FWPA levy) and universities (7.5%). The strongest capability in terms of numbers is in areas such as ecology, forest soils/productivity, forest health, genetic improvement, and wood science and technology, and the most limited capability is in harvesting and transport, socioeconomics and policy, timber engineering and extension.

Forestry research in Australia, like the sector itself, is in the midst of significant and ongoing change. Historically, state and territory governments played the major role as owners and managers of the production forest estate, and much of Australia's strength in forestry research could be found in specialised groups in state forestry agencies.

Responsibility for the management of the native forest estate is now shared amongst various agencies in different jurisdictions, while plantation forests have been progressively corporatised or privatised.

With the ongoing shift to increasing levels of private ownership, state agencies are progressively moving away from maintaining in-house research groups, with the notable exception of Tasmania. Most commentators recognise an overall decrease in forest and wood product R&D capacity in the last two decades, but a significant increase in organisational complexity and hence transaction costs. Researchers are now more widely dispersed among organisations.

In terms of numbers of personnel, almost 30% of Australia's R&D capacity sits within various divisions of CSIRO. As recently as 2008, CSIRO formed and subsequently disbanded the Forest Biosciences division, and the organisation's forest and wood products research capability is now dispersed across the divisions of Sustainable Ecosystems, Plant Industry, and Materials Science and Engineering.

While these organisational changes arguably bring to bear an even greater breadth of expertise potentially available to the sector, they represent a shift away from research that directly assists primary or manufacturing industries, and more towards broader national priorities. Nevertheless, strong capacity remains in areas such as hydrology, forest growth and physiology, tree improvement, predictive modeling, and remote sensing.

State agencies and government business enterprises collectively still account for nearly 40% of capacity in major public agencies, with five universities accounting for approximately 22%. In recent years, the overall trend among both state agencies and universities has been to dis-invest in R&D capacity in some areas of forest and wood products, although notable exceptions remain. The combined private sector R&D capacity grew along with the number and size of private plantation companies.

Although very recent data are unavailable, it seems likely that this growth in capacity will have at least halted in the last couple of years. University forestry programs face the financial challenges imposed by declining student numbers, despite ongoing demand and opportunity in the sector for graduates. Given these pressures, it will prove challenging to maintain forest and wood products targeted R&D capacity. In the longer term, declining numbers of forestry-specialised undergraduates and research graduates will also have an inevitable impact on research capacity.

In the face of more dispersal of researchers, diminishing resources and, more arguably, increasingly complex research challenges, cooperative mechanisms play an increasingly important role. The cooperative research centres program has been the main cooperative RD&E mechanism since 1991. The CRC for Temperate Hardwood Forestry, created in 1991, was superseded by the CRC for Sustainable Production Forestry in 1997; this, in turn, was superseded by the CRC for Forestry in 2005, which will reach the end of the current funding term in 2012. The CRC for Hardwood Fibre and Paper Science (1993-99) and the CRC for Wood Innovations (2001-08) were major initiatives in forest product R&D. Overall, the CRCs act, or have acted, as focal points for coordinated RD&E in specific areas.

If extended beyond 2012, the CRC for Forestry will continue to coordinate RD&E on some key issues, including processing and adding value to the plantation resource, improving supply chain performance and profitability, as well as addressing management challenges for forest estates that are arising across an increasing array of values, including carbon. An

Mauricio Acuna making assessments out in the field.

Mila Bristow and Paul Killey, ANU/CRC Forestry Phd Student taking physiology measurements from the leaves in the canopy to provide data for forest growth models.

important feature of the CRC program is its commitment to end-user driven research, and the commitment of resources to facilitate industry engagement and uptake of research results.

What is innovation, and why does it seem so difficult to make it happen?

At first glance, innovation seems like a simple concept: the creation or adoption of something new. However, innovation is expressed in the forest and wood products sector in a variety of ways. It may mean bringing a new or improved technology, process or service into a company. It may mean designing a new or improved product. It may mean changing the way a company is organised or conducts its business. It may mean tapping into human ingenuity to dream up processes, products and solutions that no one has ever thought of before.

Innovation is more than just invention or discovery. History is littered with significant inventions that failed to produce genuine innovation. The Chinese invented gunpowder 1,200 years ago, the Romans invented the steam engine in the first century AD, crop rotation was known about in the Middle Ages. What happened to these inventions? The Chinese made fireworks. The Romans made a small number of steam engines for their novelty value. Many centuries passed before crop rotation became the norm in Europe. True innovation occurs when a problem or significant need for a product or process is matched to the discovery of new knowledge – an invention, for example – or a new opportunity to access existing knowledge. Innovations based on research – the discovery of new knowledge – will only come about in an environment where the need for that knowledge and the opportunity to use it are well understood.

Research can be about identifying solutions to problems, but research on its own does not necessarily lead to innovation. If we wish to innovate, to solve problems, to move forward as an industry, we must match resource push and market pull. In a study of nine forest products innovations published in 2004, Lyndall Bull and Ian Ferguson identified market pull – end user need – as one key factor in the success of innovations in the forest products sector. Companies that were successful innovators tended to have a firm-wide learning culture, as well as appropriate technology governance structures.

Innovation has long shaped Australia's forest sector. Modern forestry benefits from innovations from the cellular to the global. Genetic research continues to refine our capacity to breed trees for specific purposes or characteristics, whether it's pulp yield, wood stiffness or drought tolerance. At the other end of the scale, innovation in the application of airborne or satellite-based remote sensing has created efficiencies in inventory or capacity to monitor forest health, quickly and at a broad scale. Thanks to innovation, the sector continues to improve its environmental record. Australia holds its place among world leaders in certification of sustainable forest management.

Forest and wood products innovation has gone through many phases, although, interestingly, sustainability has been a recurring theme since long before it came into currency in other sectors. Initially, because harvesting was the main industrial activity, attention focused on improving how trees were removed from the forest. When the sector shifted its focus to production, innovations emerged to improve productivity and trim supply and manufacturing costs. More recently, the sector has taken another turn.

Bob Barbour assessing for potential hybrids within seedlings.

In an increasingly complex socio-political environment, forestry has become more about managing forests not just for production, but for a whole raft of products and services that society wants and needs. Foresters are concerned with biodiversity, water quality and yield, carbon sequestration, aesthetics and recreational amenity, as well as the production of various forms of cellulose for industrial purposes. Research and innovation must address these issues, and some of the inherent conflicts and tradeoffs that exist among them.

In that context, the writings of Jack Westoby warrant a fresh look. Westoby's influence on forestry is not that of the great technical innovators but, by contrast, was concerned with the question of 'why' forestry rather than the 'how' – the social purpose of forestry. That forestry has an important social purpose should be news to none of us. In today's world, Westoby's concern is turning out to be the more relevant.

Drivers for innovation

The national RD&E strategy for the forest and wood products sector identifies six key drivers for the sector that will determine demand for research and innovation into the foreseeable future. These are:

- Competitiveness;
- Competition from substitutes;
- Changing nature of the resource;
- Climate change;
- Realising and demonstrating sustainability; and
- New opportunities for wood and wood fibre

These drivers suggest a vast array of potential research responses, and the wish-list, even when carefully prioritised, always seems to significantly exceed the capacity and resources that can be brought to bear. Future priorities for research and innovation will have to address outcomes in three domains: sustaining profitability and competitiveness, managing production forest landscapes for multiple values, and ensuring social benefit and hence social license for the industry.

Profitability and competitiveness require a responsive and forward-looking research and innovation response. Innovations are urgently needed to improve efficiencies at all points along the wood and wood products supply chain, and research is needed that takes account of the interactions between these points, for example, how breeding and silviculture affect harvesting performance. There is still much to be gained by

improving understanding of interactions between genetics, environment and management, for existing and prospective new regions.

But if we focus too much on present markets and environments, at the expense of future markets and demands, we do so at our peril. In shaping our research to address future needs, we must make every attempt to anticipate, and even contribute to the creation of, future markets for wood and wood-fibre products. Breeding, silviculture, site and species selection strategies implemented now will impact on supply 10, 20 or 30 years into the future. Along with developing new processing technologies for existing resources, it will be important for at least some of our research effort to focus on new processes and applications for new resources, in present and new environments. Research and innovation will contribute to the ability of new wood-based products – ranging from building components to fossil fuel replacements – to compete with other materials, in terms of performance, cost-competitiveness and social acceptability.

Social acceptability of, even desire for, forest products will increasingly hinge on the ecological footprint of these products. In addition, forest managers must increasingly take account of multiple values in their own right. Part of the research and innovation challenge is to shift focus from the coupe to landscape to estate scale, and to develop tools that enable us to evaluate multiple outcomes at this scale as a consequence of different management options. Much of the current debate about production, carbon stocks, water and/or biodiversity still struggles to take account of outcomes at a whole of estate or whole of landscape scale. As a result, forest managers often find themselves operating in a policy and regulatory environment based more on politics than on evidence. The pressure is on the research community to supply that evidence, in a manner that makes sense for operational and strategic decisions in production forest landscapes.

Research on social and socioeconomic dimensions of forestry has, in recent years, become more accepted and valued by the sector, perhaps because we are now starting to see more rigorous and apolitical approaches emerging under the leadership of some key research groups. The challenge will be to move from a reactive and analytical stance, examining the impacts of land use and land use change on communities; for example, to a more proactive position, whereby land-use change and forestry expansion can be tailored to maximise the benefits to society, particularly regional communities.

No future forestry research wish-list would be considered complete without at least passing mention of climate change. This issue applies to forestry both in terms of the opportunities emerging for the sector (expansion for carbon sequestration and renewable energy, for example), and in terms of the need to anticipate and adapt to changing climates, reducing risk and maximising gain where possible. While the debate about an appropriate response to climate change continues, it may be equally helpful to focus at least some of our attention on research that supports adaption to contemporary climate variability.

Overcoming barriers to adoption of research

For many years the linear, autonomous model of 'science - research - technology and then to innovation' was seen as the conventional wisdom. This model has largely been replaced by a non-linear and iterative innovation process, involving a range of actors, particularly end-users. By 2002, more than a thousand studies had been published on the innovation systems approach. Despite increased reflection on and understanding of the process, innovation can be a frustratingly slow process in the forest and wood products sector.

Extracting the roots to assess below ground stored carbon.

PhD student Helen Stephens & volunteer Jade Fountain: Carrying out small mammal trapping to assess habitat suitability in variable retention coupes.

For an industry-focused research organisation, ensuring that there are appropriate pathways to research adoption is one of our most important challenges. If possible, employing people in the organisation with experience in both camps – research and industry-based, operational management – can provide some important insights and checks on reality.

Some years ago, the CRC for Forestry established the role of Industry Engagement Manager, most recently occupied by Mark Brown. Mark and his predecessor brought skills and experience in operational forestry to the role, as well as research experience. More recently, we employed Justine Edwards, also with a combined research and operational background, to help facilitate the uptake and use by industry of some of the modeling and decision support tools that are under development. Justine quickly identified three key issues that must be addressed to ensure research uptake and innovation based on these tools: communication, allocation of adequate time, and the need to match tools to industry capacity.

Communication is an obvious, and critical element to successful innovation – conversely, the failure of adequate communication is one of the more common barriers to research uptake and adoption. Failure by end-users to adequately communicate requirements, or too commonly, failure by researchers to absorb and understand the message, acts as an obvious barrier. On the other side of the same coin, failure to communicate/understand what researchers can or can't deliver, or even what constitutes a problem that is amenable to research in the first place, results in frustration and disillusionment.

Successful innovation starts with collaboration

The most successful research, development and innovation processes start with genuine collaboration at project conception, problem identification and consideration of the range of options before deciding – collaboratively – how best to proceed. Successful innovation is rarely achieved by researchers pushing a research-driven agenda – a solution looking for a problem. The researcher must also be prepared to be candid about what can and can't be solved or achieved using a particular approach, while end-users need to accept that not every problem will necessarily lend itself to research.

Communication must continue throughout the life of the project. The stereotypical researcher who takes the funding, disappears for three years and then comes back at the end with a solution to a problem that no-one knew they had in the first place, unfortunately has at least some basis in reality.

Communication as a means of building trust is also important. In the case of modeling tools or decision support systems, shrouding the working processes of the models in mystery will undermine trust and confidence. The more decision makers understand the workings of decision support tools, the more likely they will be to use the tools and trust the results.

An ongoing commitment to training, good support documentation and decision tools that generate economically relevant decisions all contribute to the likelihood of successful adoption, and resultant innovation.

Allocation of adequate time for training, trialing of innovations and adapting existing processes is often inadequate. Operational managers and decision makers in the forest sector invariably have full schedules. Taking time out to try something new may be difficult, even if there is a commercially compelling case, or the results offer significant time-saving in the long run.

One lesson from the rollout of the Bluegum Productivity Optimisation System has been that while companies recognise and value the tool, there is often insufficient time to integrate it with existing in-house systems, or for staff to become fully conversant with its use. Researchers need to be cognisant of the structure of datasets included in industry, in-house systems, adapting model input protocols to fit, rather than expecting industry to restructure their data management.

Staff turnover adds an existing complexity, highlighting the need for a well planned and ongoing training schedule. Ongoing research should lead to continual improvement, but there are costs as well as benefits to staying abreast with the very latest advances, particularly if these create only incremental improvements. But in the absence of companies or forest growers willing to engage in trialing, adoption pathways become much harder to find via adaptive improvement and the integration of research results into operational practice.

With the best will in the world, there are still mis-matches between the skill sets required for innovation and operational forestry. Personnel with experience in both research and operational decision making are rare, and it is even more unusual for an individual to maintain currency in both spheres. Unlike agriculture, there are relatively few extension practitioners in the forestry sector, whose skills include the capacity to translate on both directions. Nevertheless, these barriers to innovation can be overcome by a variety of mechanisms, including:

- One on one contact between the tool developer and tool user;
- Validation of research outputs in an operational setting, thereby building confidence in the reliability of research results; and
- Integration between research products and existing in-house systems.

For research to result in genuine innovation, researchers need to be engaged, flexible and prepared to take on board operational intelligence. Operational foresters need to be willing to participate in training, validation, and to have the confidence and opportunity to participate in the research and development process. Again, agriculture has some valuable lessons, including the adaptive learning approaches that have now become widespread in many agricultural sectors. For both researchers and end-users, commitment to engagement is critical to building confidence and to collaborating in the innovation process.

Acknowledgements

Parts of this article draw heavily on the recently produced *RD&E strategy for forest and wood products*. While this strategy drew on inputs from a wide variety of participants, I am grateful to Ric Sinclair and Glen Kile for their kind permission to reproduce some of the key findings here. Justine Edwards and Mark Hunt from the CRC for Forestry shared insights on barriers to innovation and adoption.

References and further reading

Agtrans Research (2007). *Evaluation of Benefits Delivered from FWPRDC Sponsored R&D Projects PR07.5058*, summary report to Forests & Wood Products R&D Corporation, Agtrans Research, Brisbane.

Agtrans Research and eSYS Development (2008). *Economic Assessment of Selected Investments of the Cooperative Research Centre for Forestry. CRC for Forestry* Technical Report, Agtrans Research, Brisbane.

Bull, L. and Ferguson, I. (2004). "*Factors influencing the success of wood product innovation in Australia and New Zealand*" Forest Policy and Economics (8) 2006 pp 742 - 50

CRC for Forestry (2009). Highlights and Achievements 2008/09. CRC for Forestry Ltd Hobart

National primary industries research, development and extension (RD&E) framework (2010): *RD&E strategy for the forest and wood products sector*. Forest and Wood Products Australia, Melbourne.

Turner J and Lambert M (2005). Expenditure on forest and forest products research in Australia 1981–1982 to 2001–2002. *Australian Forestry* 68:3, 202–210.

Turner J and Lambert M (2009). *Expenditure on Forestry Research and Forest Products Research in Australia 2007–2008*, report prepared for Forest and Wood Products Australia, Melbourne.

URS Australia (2007). *Australia's Forest Industry to 2020*, report prepared for the Department of Agriculture, Fisheries and Forestry, Canberra.