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Editorial Board

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discipline-related referees who remain anonymous to
ensure a process of objective reviewing of the papers.
Foreword

Welcome to this special issue of the *Australian Farm Business Management Journal* on challenges and opportunities facing Australian agriculture over the next two decades.

Harsh environment (especially severe floods and droughts) and uncertain world markets are the two key factors that make farming in Australia extremely challenging. Proudly, Australian agriculture has been performing very well, contributing $34 billion in 2010-11 to the Australian economy, thanks to the men and women of rural Australia for their dedication and resilience. There are no grounds to be complacent, though. There are still challenges, remaining and emerging, to be overcome and it is utterly important to address such challenges with foresight to ensure our agriculture to continue to perform well. It is fortunate that in this special issue of the AFBM Journal, we have the contributions addressing such challenges by a number of scholars, industry leaders, practitioners, and government officials. On behalf of the Journal and the rural industries, I thank all the contributors for sharing their wisdom with us. Sincere thanks are extended to all the reviewers for sparing their valuable time to help review and improve the papers. Thanks are also due to Kerry Madden for her skilful administrative support.

I do wish that the wisdom and forethoughts shared by the authors and reviewers on how various challenges should be handled for the future will stimulate more discussions, resulting in the development of better tactics and strategies for further advancement of Australian agriculture.

Professor Zhangyue Zhou  
Director, AusAsia Business Studies Program  
James Cook University
Introduction

This special edition of the *Australian Farm Business Management Journal* brings together perspectives from across the agricultural sector on the key challenges and opportunities facing rural industries. Importantly, not only do the authors critically assess the current state of agriculture in Australia, they also provide valuable insights into the policy, investment and management decisions required to enhance the capacity of the sector to meet the much publicised challenge of feeding an extra two billion people by 2050. The renewed emphasis on food security since the price spikes of 2008 has focused debate in Australia on future production systems in a changing climate, the impact of carbon and water markets, competition for land use, the role of foreign investment, a sustained high value Australian dollar and the level of public funding devoted to research and development.

Bill Malcolm's paper "Changing business environment: Implications for farming" aims to set the scene by identifying the major changes occurring in agriculture that are, and will directly affect agricultural production. The paper demonstrates the need for on-going productivity improvements on-farm. Australia has traditionally exported around two-thirds of its agricultural production. Increased demand for calories for a growing population coupled with an increased demand for protein-based foods as incomes rise could have important implications for the production mix in Australia and successful farmers will be those who can adapt to changing markets while sustaining and enhancing the productive base of their land.

Australian and international research has consistently demonstrated the strong link between research and development and productivity. Public sector investment in agricultural R&D is coming under increasing scrutiny and is addressed in John Mullen's paper "Public investment in agricultural R&D in Australia remains a sensible policy option". It is suggested by some that a declining public investment in R&D will be replaced by private sector investment. This issue is covered by Mick Keogh's paper "Private sector investment in agricultural research and development in Australia".

The global economy still faces many challenges, and for some the Global Financial Crisis, has become a convenient excuse for a retreat to protection. This overlooks the clear benefits of open and fair markets as a stimulant for economic growth. Australian researchers have a rich tradition in contributing to the economic arguments for open markets. Successive Australian Governments have supported this approach and Australia has clearly played a leading role in the push for global trade reform. With the current Doha Round of the WTO effectively stalled, there is increasing focus on alternate approaches, such as bilateral and multilateral trade negotiations. In the context of international trade, Australia must be vigilant on biosecurity, as demonstrated in the paper by Mike Nunn.

Sustaining the production base is critical for the future of Australian agriculture. Farmers are stewards of much of the landscape. Not only do they pursue this task in an environment that famously shifts from ‘droughts to flooding rains’, but they also have to face a shifting policy agenda. David Pannell’s paper on “Environment protection and challenges for future farming” identifies a growing tension with respect to land use for agricultural purposes which also is increasingly expected to respond to societal demand for environmental protection. While this issue is not insurmountable, it does reflect increasing competition for land and could also be a symptom of the growing divide between rural and urban Australia.

The environment is also addressed in the timely paper "Towards a more nuanced discussion of the net-benefits of sharing water in the Murray-Darling Basin" by Morrison et al. This paper seeks to consolidate information on water sharing in the Murray Darling Basin and present it in a way that will help refocus the current debate on the benefits derived from water sharing. It is important that debates focus on facts in relation to such 'politically-charged' issues. It could be argued that the facts have been lost too much in the current debate over the Murray Darling Basin Management Plan.

Sam Nelson’s paper, “Finding tomorrow’s agricultural workforce” addresses a critical issue for the future of Australian agriculture. Increasing competition from other sectors, especially mining, has focused the attention of farm leaders on how agriculture can compete in the market for skilled workers, but also how we can encourage more young people to see agriculture as a worthwhile career choice. Many may be daunted at the prospects of fly-in, fly-out options for agriculture as we have seen in the mining sector, but this may be the reality if we cannot arrest the trends in the agricultural workforce.

The future of the Australian ‘family farm’ is also greatly affected by the age profile of Australia’s farm workforce. Who takes over the farm is a real challenge facing many Australian farm families. Succession planning is an issue addressed in a paper by Mike Stephens, which also highlights the importance of contract law for forward planning in farm management. The importance of understanding important legal issues is also emphasised in the paper by Tony Smith.
Of course, these issues are all known challenges, there is also the unknown. Twenty years ago, who would have thought that mining would be competing with agriculture in traditional farming country in NSW and Queensland, that farmers could trade carbon, that agricultural colleges would be struggling for students and that farmers would be receiving payments to be stewards of the land. Farming in Australia has always adapted to changing circumstances. Our capacity to adapt is significantly enhanced by having better research outcomes, better policy settings and the confidence of government and the private sector to invest in the much needed infrastructure to support a vibrant agricultural sector.

There is every reason to believe that Australian agriculture has a bright future. We commend this special edition to you as an excellent summary of the known challenges facing agriculture and the policy options that can enhance our capacity to capitalise on the opportunities presented by a growing demand for the products we produce.

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The character of *AFBM Journal*

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AFBMNetwork vision and mission statements actively encourage the design of farming systems matched to the environmental, social, economic and marketing conditions of Australasia. It promotes quality education, research, consultancy and extension to service the primary sector and its organisations. The *AFBM Journal* will therefore publish quality papers related to the areas of Animal Systems and Technology; Cropping Systems and Technology; Ecological Agriculture; Farm Economics; Global Perspectives of Agriculture; Business Management and Decision-Making; Social Issues of Farming and Sustainable Farming Systems.

The Department of Education Science and Training of the Commonwealth of Australia – Higher Education Research Data Collection (DEST-HERDC) defines that the *essential characteristics of a research publication* are as follows:

- substantial scholarly activity, as evidenced by discussion of the relevant literature, an awareness of the history and antecedents of work described, and provided in a format which allows a reader to trace sources of the work through citations, footnotes, etc
- originality (i.e. not a compilation of existing works)
- veracity/validity through a peer validation process or by satisfying the commercial publisher or gallery processes

*AFBM Journal* supports the above principles and while encouraging the publication of research results, useful to the professional farming related community, will undertake a stringent process of peer reviewing to ensure the quality of the papers published in the different issues of the Journal.

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Instructions for intending authors of papers to be submitted to the *AFBM Journal* can be downloaded from AFBMNNetwork webpage. Papers must be submitted online to the following email address: kparton@csu.edu.au. Further enquiries must be addressed toward the same email address to the Chief Editor of the *Journal*, Professor Kevin A Parton.
Public investment in agricultural research and development in Australia remains a sensible policy option

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Abstract. There is evidence that productivity in Australia's broadacre agriculture (extensive cropping and livestock industries) has been slowing in the past decade. A series of poor seasons has been partly responsible, but an econometric analysis of structural changes in the trend of total factor productivity (TFP) indicates that stagnant public investment in agricultural R&D has also made a significant contribution to this slowdown in TFP. Related econometric analysis of the returns to public investment in agricultural R&D in the broadacre sector confirms that the rate of return to investment remains high. Despite these findings, a recent enquiry by Australia's Productivity Commission into the financing of rural research suggests that the public sector may be 'crowding out' private sector investment in agricultural R&D and recommends a reduction in public support. In this paper I briefly review the econometric analyses to date and the trends in TFP and public R&D investment. While I have not been able to conclusively test the 'crowding out' hypothesis, there seems to be little empirical evidence to prefer this hypothesis to a more traditional 'market failure' hypothesis. Clearly, stakeholders in agricultural R&D in Australia have to do a better job in communicating the case for public investment in agricultural R&D. Other developed countries are experiencing the same phenomenon and it may become an issue in the future for developing countries in Asia.

Keywords: total factor productivity, returns to research, crowding out.

Introduction

Agricultural R&D can be thought of as adding to a knowledge stock that has an impact on productivity for 35 or more years. This is an important source of wealth in countries making these investments. Moreover, new technologies developed in rich countries able to make the largest investments have 'spilled over' to poor countries and hence public R&D has been an important source of wealth and poverty alleviation across the world. The need for continued productivity growth is evident with world population still to grow by another 2-3 billion and the challenges for productivity from climate change to be met in coming decades.

Despite these challenges, public investment in agricultural R&D is under threat in many developed countries (Pardey et al. 2006). Moreover, evidence is also emerging of a slowdown in productivity growth in agriculture in at least some rich countries, likely in part as a consequence of a slowdown in R&D investment.

The continuing unresolved controversy about the role of government in funding agricultural research in Australia is evidenced by the four enquiries held by the Productivity Commission (PC) (or its forebears) since 1976. The Productivity Commission has usually recommended that the maximum government grant matching the levies collected by the Research and Development Corporations (RDCs) be reduced from its present level of 0.5% of the gross value of the relevant industries. One reason for this recommendation is that the PC argues that public support to agricultural R&D far exceeds that to other industries. The extent of this 'excess' support is disputed in submissions to the 2011 PC enquiry by the Australian Farm Institute and ABARES, for example, but this argument is not pursued here. The PC also argued that were the grant to be reduced, the RDCs would make up any shortfall by increasing their levy rates. This is a variant of the hypothesis that government investment is 'crowding out' industry investment.

The 2011 Inquiry followed past inquiries in recommending a halving of the cap for a matching grant to 0.25% of industry Gross Value of Production (GVP) over ten years. A notable departure from previous inquiries was the recommendation for an uncapped contribution of 20 cents for every $1 raised from industry beyond the cap for the matching grant, thus providing industry with an ongoing incentive to increase investment in R&D.

The alternative view presented to the PC enquiries is that the public good characteristics of R&D give rise to socially suboptimal levels of investment by industry and this market failure requires some continuing public investment, even in R&D, delivering benefits largely to industry1. The development of the RDC model has

* I have benefited from insights (and data) from colleagues at ABARES and from those who attended seminars at the SA Branch of AARES and James Cook University, Townsville.

1 There seems little argument that there is likely to be market failure in the provision of research service related to environmental and social outcomes although there is a naive argument held by some that where community benefits are jointly provided by, say, RDC supported research, no further investment is required by the public sector to capture these outcomes for the community.

ameliored but not solved the market failure problem.

My purpose here is to assess the extent to which the limited empirical evidence about the relationship between investment in R&D and productivity growth supports (or not) these competing hypotheses about the role of government in funding agricultural R&D. First there are brief reviews of trends in public investment in agricultural research in Australia and in productivity in Australian broadacre agriculture. Then follows reviews of econometric work first, linking the slowdown in productivity growth with the slowdown in public investment and climate and second, estimating the rate of return to public investment in R&D in broadacre agriculture in Australia. Finally, I discuss how consistent this empirical evidence is with the ‘crowding out’ and ‘market failure’ hypotheses.

**Trends in public investment in agriculture in Australia**

The way in which the data on R&D investment have been assembled from ABS sources and from a previous dataset developed by Mullen et al. (1996) is described in Mullen (2007). Expenditure is attributed to research providers, rather than funders. As a result, expenditure by state departments of agriculture or universities, for example, includes funds obtained from rural RDCs. Attention is focussed on farm production research and investment. R&D in fisheries and forestry, in environment and social outcomes and in the processing of farm products is not included. The GDP deflator was used to express investment in R&D in 2008 dollars.

Total public expenditure on agricultural R&D in Australia has grown from A$140 million in 1952-53 to almost A$830 million in 2006-07 (in 2008 dollars) (Figure 1) (Mullen 2010a). Expenditure growth was strong to the mid-1970s, but has essentially been static since that time although there was a spike in investment (nearly A$950 million) in 2001. Likewise, agricultural research intensity, which measures the investment in agricultural R&D as a percentage of GDP, grew strongly in the 1950s and 1960s, but has been drifting down from about 4.0-5.0% annually of agriculture GDP in the period between 1978 and 1986 to about 3.0% per annum in recent years (as compared to 2.4% per annum in developed countries).

A feature of the agricultural research sector in Australia has been the prominent role played by the RDCs. In approximate terms, RDCs commission agricultural research on a competitive basis among public and private research providers using funds from levies on production and matching Commonwealth grants (up to 0.5% of the value of production). The attraction of the RDC system is that it ameliorates the non-excludability characteristic of information generated by research, while preserving the benefits from its non-rival nature. In 2007, total expenditure by the RDCs on production agricultural research (excluding the fisheries, forestry and energy RDCs and Land and Water Australia (LWA) was A$478 million ($2008), which is almost 60% of total public expenditure on agricultural R&D. Some of this investment by the RDCs is directed towards the processing sectors rather than production agriculture and some is directed to environmental outcomes. If these investments outside production agriculture amount to a third of the total then it seems likely that the RDCs are funding 40 – 50% of research into production agriculture in Australia. Recall also that over half of these RDC funds are raised from farmers. In the 1980s, RDC funding amounted to less than 15% of total public expenditure on agricultural R&D.

**Productivity growth in Australian broadacre agriculture**

The estimates of productivity growth in Australian broadacre agriculture used here were based on farm survey data from the Australian Bureau of Agricultural and Resource Economics (ABARE). A more thorough review of the trend in agricultural productivity in Australia and its estimation can be found in Nossal et al. (2010). Productivity growth is measured as the growth in outputs less the growth in inputs.

Starting from 100 back to 1952-53, the estimated multifactor (MFP) index increased to 218.3 in 2006-07 with the annual growth rate of 2.0% a year (Figure 2). The index is highly variable, falling in 20 of the 55 years, reflecting seasonal conditions. Such variability makes it difficult to discern trends in the underlying, more stable rate of technological change.

Changes in productivity can be compared with changes in the terms of trade faced by farmers as a partial indicator of whether Australian agriculture is becoming more or less competitive. The conventional wisdom is that the terms of trade facing Australian agriculture have been declining inexorably.

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2 The terms multifactor productivity (MFP) and total factor productivity (TFP) are used equivalently. The former term recognises that in practice not all factors can be measured and included in the index.

3 Reported in ABARE (2008) and estimated as the ratio of an index of prices received by farmers to an index of prices paid by farmers.
The real situation was a decline of 2.6% per annum from 1953 to 1990, and less than 1% per annum from 1991 to 2007.

A better indication of ‘competitiveness’ is the growth in productivity in agriculture relative to that in the rest of the economy. Mullen (2010b) reported ABS data suggesting that in recent decades productivity in the agriculture, fisheries and forestry sector often grew at three times the rate of that in the rest of the economy⁴. The agricultural sectors in few other OECD countries have performed as well. Hence, productivity growth in the Australian agricultural sector has likely been strong enough to enhance the sector’s competitiveness relative to other sectors of the economy and relative to the agricultural sectors in many other countries.

The ABARE broadacre dataset can be stratified to provide estimates of productivity growth by the enterprise or industry: cropping, mixed crop–livestock, beef, and sheep. Since 1978, cropping specialists have achieved much higher rates of MFP growth (2.1% per year) than have beef specialists (1.5% per year) and sheep specialists (0.3% per year) (Table 1) (Nossal et al. 2010). Generally output grew while input use stayed static or declined. In particular, cropping specialists greatly increased their use of purchased inputs (4% per year) and reduced their use of labour (-0.2% per year) and capital (-0.4% per year). A switch toward reduced-tillage cropping—which is also associated with more diverse cropping rotations and more opportunistic cropping to exploit available soil moisture (as opposed to fixed rotations and fallows)—partly explains the changes in input use and the strong rate of productivity growth.

However, recent data suggest that productivity growth in Australian agriculture — and that of other developed countries (Pardey et al. 2006) — has slowed in the 10 years leading up to 2007. From 1998 to 2007 productivity fell at the rate of 1.4% per annum (Table 1). Trends in productivity have not been even across industries within broadacre agriculture (Table 1). For cropping specialists, MFP grew by 4.8% per year from 1980 to 1994 but declined by 2.1% per year from 1998 to 2007. There seems much less evidence of a slowing in MFP growth for beef and sheep specialists. Nossal et al. (2010) speculated that productivity growth of sheep specialists, usually ranking the lowest among the industry groups, might finally be catching up.

Why might broadacre productivity be slowing?

Some argue that it is not surprising that productivity growth in agriculture is drifting down because “all the big gains have been made.” However, Australian research agronomists seem confident that there are still practical research opportunities to develop new technologies that would allow farmers to grow crops more efficiently. Anderson and Angus (World Wheat Book, in press) said: “Despite the new technology, the mean yield is only 2.0 tons per ha, about half of the water-limited potential…. Further research will be needed to increase yield closer to the water-limited potential. The gains are most likely to come from tactics that enable crops to take advantage of the more favorable seasons in the variable climate, and concentration of inputs on the parts of farms with the highest yield potential.”

Another factor likely to explain a significant portion of productivity growth in broadacre agriculture (at least at the aggregate level) is climate or seasonal conditions. No doubt some of the recent productivity decline is due to the run of poor seasons shown by the rainfall anomaly⁵ for the Murray Darling Basin from 2000–2008 (Figure 3), but recent research by Sheng et al. (2010) has demonstrated that the stagnation in public investment in R&D from the late 70s is now also contributing to the slowdown in MFP.

Econometric analyses of the relationship between public investment in Australian broadacre agriculture and productivity growth in broadacre agriculture

Two approaches have recently been applied to examine the relationship between productivity growth and public investment in research in broadacre agriculture in Australia. One approach used time series techniques to assess whether there have been changes in the trend in broadacre productivity and, if so, what factors might explain any trend changes. The second approach updates traditional regression analyses of the factors including public investment in R&D and productivity growth and goes on to estimate a return to investment.

Analysis of the Trend in Broadacre Productivity

Sheng et al. (2010) tested whether Australian broadacre productivity growth had slowed and, if so, when and why. TFP is highly variable due, in part, to unstable

⁴ Mullen (2010a, b) explained difference in the ABARE and ABS MFP series for Australia.

⁵ The anomaly is the annual deviation in rainfall from average annual rainfall between 1961 and 1990.
seasonal effects. Therefore, detecting fundamental shifts in the long-term trend required suitable statistical methods. An analysis of recursive residuals from regression models (the CUSQ method) was used to examine the systematic deviation from trend in current total factor productivity (TFP) in Australian broadacre agriculture between 1952-53 and 2006-07. They found that a significant structural change or ‘turning point’ occurred in the TFP series in the mid-1990s. Further, it was likely that the slowdown was likely due to a combination of adverse seasonal conditions and stagnant public R&D expenditure since the late 1970s.

The rate of return to public investment in broadacre agricultural research

Mullen and Cox (1995) conducted the original econometric analysis of the relationship between public investment in research and productivity growth in Australia’s broadacre agriculture. Using a dataset extending from 1953 to 1994 they estimated that the rate of return to research was in the range of 15 – 40%. This original study was updated on several occasions (Mullen 2007) but the most comprehensive revision using a dataset extending to 2007 and an exhaustive estimation strategy based on Alston et al. (2010) was reported in Sheng et al. (2011).

Estimated models typically are variants of the following form:

\[
\ln(TFP_t) = \alpha + \beta_1 \ln(TS_t) + \beta_2 \ln(EXT_t) + \\
\gamma_1 \ln(WEA_t) + \gamma_2 \ln(EDUC_t) + \gamma_3 \ln(TOT_t) + \epsilon_t
\]

where TS is a stock of knowledge available to farmers generated by research, EXT is another knowledge stock variable this time generated by extension activities. Control variables include a measure of seasonal conditions (WEA,) farmer’s level of education attainment as a proxy for the unobserved human capital of broadacre farmers (EDUC,) and the farmers’ terms of trade for Australian agriculture (TOT,).

Estimating models of this nature require consideration of a wide range of specification issues. Economic theory is not prescriptive with respect to these issues. Following in the spirit of Alston et al. (2010) but not as exhaustively, Sheng et al. (2011) conducted an extensive econometric analysis over a range of specification issues to identify a set of models with good econometric properties with a view to assessing how robust were findings with respect to rates of return to investment.

Ideally the focus of such empirical work should be the relationship between R&D and the technical change component of TFP. Other components of TFP are technical, scale and mix efficiencies (O’Donnell 2010). Investment in extension accounts for technical efficiency but no account is taken in this model of gains in TFP from scale efficiency (Hughes et al. 2011).

A key issue is the derivation of knowledge stocks generated by R&D. They are normally derived as weighted averages of a past stream of annual investments. The weights depend on the length and shape of the distribution function used to define the impact of R&D through time on the knowledge stock. Sheng et al. considered five distribution functions for lag lengths of 16 and 35 years and a key property in discriminating between models was their root mean square error (RMSE). The distributions they considered were (see Figure 4):

- ‘Trapezoid’ used previously by Mullen with peak impact in years 9 -15;
- ‘Gamma’ with peak impact at 7 years;
- ‘Gamma_T’ with peak impact at 13 years similar to the Trapezoid;
- ‘Pim’ the permanent inventory method used in studies of industrial R&D at depreciation rate of 15 per cent from peak impact in year 1.
- ‘Gamma_P’ mimicking ‘Pim’.

The distribution preferred by Sheng et al. was the unconstrained gamma model (even though the peak of research impact in year 7 is somewhat counterintuitive). However the Gamma T and Trapezoid models also had good econometric properties. They found the 16-year lag models had poor properties for all distributions.

Other key choices involved the treatment of private investment in broadacre R&D and foreign research activities that impact on productivity in Australian broadacre agriculture. Sheng et al. (2011) followed Mullen and Cox (1995) in omitting Australian private agricultural R&D largely because until recent years it has been very small relative to public investment and higher levels of investment in recent years are unlikely to have yet had much impact on productivity.

An important contribution of Sheng et al. is that they have successfully incorporated the influence of foreign research activities in their model. Problems with multicollinearity meant that the separate influences of the Australian public and US public knowledge stocks could not be estimated, but the model above, where the TS knowledge stock is the weighted sum of the two knowledge stocks (where the weight on the US stock was 0.1), was preferred to the original Mullen and Cox model which ignored foreign ‘spilling’.

Other specification and estimation issues included choices about:


- Linear v log-linear v quadratic functional forms;
- OLS v ARIMA estimators.

A log-linear functional form and the ARIMA estimator were preferred.

Sheng et al. (2011) preferred the model where domestic and foreign public knowledge stocks were incorporated in TS derived from an unconstrained gamma distribution over 35 years estimated in log-linear form using an ARIMA estimator. From this model the estimated internal rate of return to a one-year increment in Australian public investment in R&D was 28.4%. Two counterintuitive aspects of this model are that peak research impact occurs around year 7 and that foreign ‘spillins’ contributed twice as much to broadacre productivity gains as domestic public R&D. The models based on the ‘Gamma_T’ and the Trapezoid distributions impose a peak impact in later years. Their results suggest that the influence of foreign and domestic R&D is similar and give estimated IRRs of 14% and 15.4%, respectively. The IRRs for the Mullen and Cox model ignoring foreign R&D were a few percentage points lower for each distribution type. The IRRs for models where research lags were constrained to 16 years were much larger. Sheng et al. found that when estimated over the shorter period since 1978 the returns to research increased (to 45.3% for their preferred Gamma model).

Hence, the Sheng et al. (2011) findings are consistent with previous econometric studies by Mullen (summarised in Mullen 2007) of public investment in broadacre agriculture in Australia. They are also consistent with the many reputable benefit cost analyses at a project level conducted in Australia by State Departments of Agriculture and by private consultants for the RDCs.

Mullen (2004 and extended in later seminars) reported that the average Benefit-Cost Ratio (BCR) for 10 large projects evaluated by NSW DPI economists in 2003 and 2004 was 11.2:1 (ranging from 2 to 66:1). DAFF (2001) reported that Chudleigh and Simpson (2001) had found that the average BCR for a sample of projects across several of the RDCs was 7:1. Council of the Rural Research and Development Corporations (2010) in reviewing the PC (2007) report into Public Support for Science and Innovation identified 41 benefit cost analyses for rural R&D projects spanning a broad array of industries and types of research. A simple average of these results shows a BCR of 68.5. He also summarised evaluations commissioned by the Council of the RDCs in 2008 and 2009. He found that when benefits (excluding unpriced environmental benefits) were estimated over 25 years, the average BCR was about 11:1 for about 90 randomly selected projects. Much of this material is referenced in the recent report from the Productivity Commission (2011).

Goucher also reviewed the study by Alston et al. (2000) of rates of return analyses worldwide. Alston et al. found that the average of the estimates of the rate of return to research only (from 1,144 studies) was 100% per annum. The range was wide, but less than 10 estimates (less than 1%) found a negative rate of return. Goucher summarised the findings from the 154 Australian and NZ studies reviewed by Alston et al. The average estimated rate of return from these studies was 87% p.a.

The broad conclusion from this substantial body of economic analysis of investment in publicly funded agricultural R&D both globally and in Australia is that returns are very high and this suggests that there may be a degree of underinvestment in agricultural research in Australia as well as globally.

Two further observations can be made here. First all the econometric analysis at an aggregate level and most of the project level benefit cost analysis focus on quantifying industry benefits, but ‘spillover’ benefits in the form of gains in environmental and human health and in social and scientific capacity are at best identified qualitatively. These ‘spillovers’ are widely accepted as a potential source of market failure requiring potentially some form of government intervention. One point of contention, however, is that the PC (and others) argue that providing industry benefits are sufficient there is no need for government intervention whereas some would argue that often, there is little incentive for industry to ensure that these ‘spillover’ benefits are actually taken up by the community and that some degree of public investment is required to ensure these benefits are captured by the community.

Second, the incentives facing farmers and RDCs are much higher than estimated returns to total investment in R&D. Let’s say the rate of industry returns to investment in R&D is 20%6. At present RDCs fund about half the cost of a research project, the rest coming as an in-kind contribution from a research institution (a State Department for example). Hence, the return to the RDC investment is effectively 40%. Moreover farmers provide half the funds to RDCs and so the effective return to their investment (attracting the matching grant) is in the order

6 The focus is on industry returns rather than environmental and social returns.

of 80%\textsuperscript{7}. Reducing the matching grant will mean that the incentive facing farmers for any levy funds beyond 0.25% of GVP would be 40% under this scenario (or 48% if a 20 cent per dollar invested uncapped grant is introduced).

The PC accepts that the preponderance of evidence supports the view that return to investment in research in Australian agriculture has been high. Nevertheless the PC argues that the matching grant (against the RDC levy) should be halved to 0.25% of GVP because it doubts that the matching grant has called forth much additional research from industry. It expects that were the government to reduce the GVP cap for a matching grant by 0.25%, the RDCs would increase their levies to offset this reduction. The public sector is ‘crowding out’ industry investment in other words.

**Does the empirical evidence support the ‘crowding out’ or ‘market failure’ hypotheses?**

It seems difficult (if not impossible) to develop a conclusive econometric test of either hypothesis. This is not an uncommon problem. The task is to see which hypothesis seems most consistent with limited empirical evidence and inferences or expectations based on the nature of agricultural research and the structure of the agricultural sector.

Some of the following discussion is speculative and anecdotal but raises questions worthy of further research. Starting with the ‘crowding out’ hypothesis we might wonder under what conditions would industry, in this case RDCs, not invest in research in the presence of public investment. The PC seems to be arguing that the present level of matching grant is not attracting ‘additional’ investment by industry. They speculate that this research would have been done anyway because of the high rates of return being earned and hence were public funding withdrawn as recommended, the RDCs would be able (at some time lag) to increase levies to replace these public funds. There does not appear to be any historical precedent (of a withdrawal of government funding) to test this ‘crowding out’ argument by the PC. However if it were true, then an obvious question, not addressed by the PC, is why more RDCs have not already raised levies beyond 0.5% in pursuit of these high returns (the GRDC and AWI are the exceptions).

Another more likely scenario in which investment by RDCs would be ‘crowded out’ by the public sector is one where the returns to their investment in research were low relative to other investment opportunities available to farmers. Under this scenario withdrawing public funds might result in an increase in the returns to research investment sufficient to attract increased investment from the RDCs (providing the research production function is characterised by diminishing returns to investment at this point). Under this scenario one might also expect it to be common that RDCs set levies below the maximum 0.5% matching grant level.

Neither of these conditions is observed, in fact just the opposite. Few RDCs set levies below the 0.5% level and few set levies above this level. Further, as described above, the rates of return to public investment in research have been high for several decades. Perhaps the ‘crowding out’ hypothesis is consistent with high rates of return if either the research production function showed a high degree of diminishing returns at this point where levies are set at 0.5% or if a constraint to research such as the supply of scientists becomes critically binding at this point. The arguments are reviewed here but the case is difficult to make.

In the first case the argument might run that RDCs are unwilling to invest beyond the 0.5% level because their incentives are sharply diminished past this point, but that up to this point they may be prepared to replace public investment because the returns are sufficiently attractive\textsuperscript{8}. There are no historical precedents to shed some light on this, but there is some empirical evidence about the shape of the research production function.

Intuitively we would expect some degree of curvature but recent empirical analyses provide little evidence that it is strong. Sheng et al. (2011) estimated higher returns to research for a model estimated over the shorter time frame from 1978. Given that real public investment in agricultural R&D was at best stagnant over this period, this provides some circumstantial evidence of diminishing returns. However they also found that no gains in model performance could be had from using a quadratic functional form – conducive to the possibility of sharply diminishing returns to investment – instead

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\textsuperscript{7} Let’s assume that the incidence of levies and the distribution of the benefits from production focussed R&D are the same.

\textsuperscript{8} Note that the returns to farmers fall to 40% (under the assumptions of the illustrative example used here) as they go beyond the 0.5% level but they would also fall to this level were government to pull back from the 0.5% level.
of the preferred log-linear form. It has already been noted that scientists are still confident that research opportunities remain to increase agricultural productivity.

There is some concern about the supply of scientists with inferences of a severe shortage based on the age profile of the research community and the closure or amalgamation of agricultural science departments and faculties. Yet there seems little evidence either in terms of growth in employment opportunities or the demand for university places, or in terms of rising salaries, of strong growth in the demand for agricultural scientists. Perhaps demand pressures will emerge in coming years.

In summing up to date, neither empirical evidence nor a logical chain of inference provides much support for the crowding out hypothesis. It is much easier to make a case in support of the traditional market failure argument.

Few would argue that the non-excludability and non-rivalry characteristics of information generated by research mean that were farmers left to act individually, investment in agricultural research would be suboptimal from the viewpoints of both agriculture and society more generally. In Australia the RDC model has been developed to ameliorate the non-excludability issue while preserving the benefits of non-rivalry.

The debate however focuses on whether the RDC model is sufficient to largely solve the market failure problem. The PC clearly thinks it does, arguing, as we have seen, that in fact government is crowding out industry at least with respect to research delivering largely industry benefits (although it does agree that some lower level of public funding is justified). Others argue that the high rates of return to research, prevailing for at least several decades, are evidence of continuing market failure. The question that then arises is why are RDCs unable to increase levies to enable industry to capture more of these high returns.

It should not be surprising that farmers understate their true willingness to pay for research under the common uniform levy of the RDC model. Remaining incentives to free ride are complemented by heterogeneity in the resource endowment of farms and in the applicability of particular technologies. In addition the long lags in the development of new technologies may be a disincentive to increasing levies. This disincentive arises not only because they may not receive any benefits in their working life, but more likely because they do not appreciate the contribution to their present farming system of past research efforts nor foresee how present research efforts may change farming systems decades hence. Some of these arguments are noted in the PC report.

Concluding comments

Salient features of the agricultural research setting in Australia are first, rates of return to investment have been high for several decades at least and second, that farmers through the RDCs show little inclination to increase the levies they pay to finance R&D beyond the 0.5% of GVP that has attracted a matching Commonwealth grant (with the GRDC and AWI being notable exceptions). The unwillingness on the part of farmers to increase levy contributions is likely explained by the non-excludable characteristic of research and the heterogeneity of farming enterprises on the one hand and the impact of new technology on the other.

This set of phenomena readily fits with a traditional hypothesis that present levels of investment in research are likely to be suboptimal from society’s viewpoint even where the outcomes of research are predominantly economic (industry oriented) in nature. Public sector investment remains an important means to overcome this market failure.

However present levels of public sector investment in Australia remain under threat with the PC again recommending that the Commonwealth matching grant be halved although the recommendation that a 20 cent per industry dollar uncapped grant (beyond the 0.25% GVP cap) be introduced seems a sensible change in the incentives for industry to invest in R&D. The PC argument is based partly on a contested assessment, not pursued here, that public support for agricultural research is much higher than for research in other sectors, and partly on a notion that the public sector is crowding out the private sector such that were the Commonwealth levy halved, the RDCs would increase the Commonwealth levy halved, the RDCs would increase the levies raised from farmers. However, crowding out would most likely be typified by low rates of return to research and pressure to reduce levy rates. Observed high rates of return are only consistent with crowding out in the unlikely scenarios of either sharply diminishing returns to future research and/or constraints on the supply of research services. The PC provides little evidence either of past research efforts nor foresee how new technologies may be a disincentive to increasing levies. This disincentive arises not only because they may not receive any benefits in their working life, but more likely because they do not appreciate the contribution to their present farming system of past research efforts nor foresee how present research efforts may change farming systems decades hence.
empirical evidence to support their recommendations.

In Australia, as in some other developed countries, productivity growth in agriculture is slowing and a decline in public investment in R&D is likely to have contributed to this slowdown. The long lag over which R&D impacts on productivity exacerbate this attribution problem, but also mean that any current slowdown in public investment will influence productivity growth in agriculture for several decades at a time when global population is still growing and costs associated with climate change are emerging. It would seem prudent to maintain public support for agricultural research rather than risk losses in economic welfare in Australia and poor countries somewhat reliant on technologies generated in Australia on the basis that public investment is crowding out private investment; a basis that has little empirical support.

The hypothesis that there remains some degree of underinvestment in agricultural research in Australia is supported by prevailing high rates of return to research investment and by a sound rationale as to why the RDC model cannot be expected to arrive at a levy on farmers fully reflective of the value of research to industry and society.

References
ABARE 2008, Australian Commodity Statistics 2008, Canberra ACT.
Council of the Rural Research and Development Corporations 2010, Submission to the Productivity Commission enquiry into rural research and development corporations, available at PC enquiry website.
DAFF 2001, Innovating rural Australia: research and development corporations outcomes, DAFF, Canberra, Australia.
### Appendix

#### Table 1: Productivity growth per annum in sectors of Australian broadacre agriculture

<table>
<thead>
<tr>
<th>Period</th>
<th>All broadacre</th>
<th>Cropping</th>
<th>Mixed crop -livestock</th>
<th>Beef</th>
<th>Sheep</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979-80 to 1988-89</td>
<td>2.2%</td>
<td>4.8%</td>
<td>2.9%</td>
<td>-0.9%</td>
<td>0.4%</td>
</tr>
<tr>
<td>1984-85 to 1993-94</td>
<td>1.8%</td>
<td>4.7%</td>
<td>3.2%</td>
<td>3.1%</td>
<td>-1.7%</td>
</tr>
<tr>
<td>1988-89 to 1997-98</td>
<td>2.0%</td>
<td>1.9%</td>
<td>1.4%</td>
<td>1.6%</td>
<td>-1.2%</td>
</tr>
<tr>
<td>1993-94 to 2002-03</td>
<td>0.7%</td>
<td>-1.2%</td>
<td>0.0%</td>
<td>1.0%</td>
<td>3.4%</td>
</tr>
<tr>
<td>1997-98 to 2006-07</td>
<td>-1.4%</td>
<td>-2.1%</td>
<td>-1.9%</td>
<td>2.8%</td>
<td>0.5%</td>
</tr>
<tr>
<td>1977-78 to 2006-07</td>
<td>1.5%</td>
<td>2.1%</td>
<td>1.5%</td>
<td>1.5%</td>
<td>0.3%</td>
</tr>
</tbody>
</table>
Figure 1: Real public investment in agricultural R&D in Australia

Figure 2: Trends in multifactor productivity and the terms of trade for Australian broadacre agriculture
Figure 3: Annual rainfall anomalies in the Murray-Darling Basin

Source: Australian Bureau of Meteorology.

Figure 4: Gamma, trapezoid and geometric distributions for research knowledge stocks
Private sector investment in agricultural research and development in Australia

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Abstract. There is growing recognition that the private sector is playing an increasingly important role in agricultural research and development internationally, and in Australia. There are only very limited data available about the extent of private sector research and development (R&D) investment that is occurring in Australia, and the nature of that investment. This paper reports the results of a survey and data review that was carried out to gain a better understanding of private sector agricultural R&D investment in Australia. The survey, whilst limited, suggests that private sector agricultural R&D investment in Australia is more significant than previously reported, and that private sector investors see public sector investment in this area as complementary, rather than competitive.

Keywords: agriculture, research and development, public sector, private sector.

Introduction
This research was conducted to gain a better understanding of the role of the private sector in agricultural research and development (R&D) in Australia. It was funded by the Australian Farm Institute, in conjunction with the Council of Rural Research and Development Corporations. This paper provides a summary of the main findings of the research.

The two main elements of the research were a review of available literature on the changing roles of the public and the private sector in agricultural R&D both in Australia and globally, and a survey of the private sector in Australia to gain a better understanding of both the scale and nature of private-sector investment in agricultural R&D.

In reviewing available literature and data on private-sector agricultural R&D, it became apparent that despite international agreement of the definition of R&D, reported international and domestic data do not use a standard definition of what constitutes agricultural R&D. This possibly arises because agricultural R&D differs from industrial R&D, in that agricultural R&D is undertaken by participants in a range of different industries (plant breeding, fertiliser manufacturers, pharmaceuticals companies, machinery manufacturers, food processors and retailers, other services providers) with different technology requirements and different market structures. Farm businesses represent only one part of the picture, and are generally not directly involved in R&D activities.

Despite the limitations imposed by inconsistent definitions, it is apparent that in most developed nations the private sector is playing an increasingly important role in agricultural R&D. Estimates vary depending on the definition used (some or all of the farm, food, forestry, fisheries and beverage sectors are included in different definitions of ‘agriculture’) but when food and agriculture are included the share of total agricultural R&D investment by the private sector averaged 54% for OECD nations in 2000, up from 44% in 1981. Unfortunately, more recent internationally comparable data is not available.

Drivers of private sector R&D
There has been a range of different factors identified that are believed to have resulted in increased private-sector agricultural R&D investment over recent decades.

The implementation of laws which create and protect ownership of Intellectual Property (IP) rights in plant and animal species is considered to be a key factor.

The size of a firm, and the share that the firm holds of the market have also been found to be related to private-sector R&D investment intensities, with larger firms that hold a greater market share more likely to invest in R&D. Appropriability, or ability to capture the majority of benefits arising from successful R&D is also important, with some areas of agricultural research being such that the benefits of successful R&D investment are not easy to capture.

Foreign Direct Investment (FDI) levels in a national industry have also been observed to be related to private-sector R&D investment. In the case where there are high levels of FDI, it appears that multinational firms are more likely to invest more in R&D in their home markets, and limit the R&D investment by their international subsidiaries to experimental development research specific to that market. This is relevant to Australia, where there is a high level of FDI in some important farm input sectors.

Public-sector agricultural R&D activities are generally believed to be complementary to private-sector agricultural R&D, with a high
level of cooperation observed to occur between the two sectors. While classical R&D theory suggests that the public sector should be involved in more basic research and work on enabling technologies that the private sector can then develop and commercialise, this is not necessarily the model observed in many situations, where a range of different factors determine altered roles for the two sectors.

**Agricultural R&D in Australia**

There is a range of official statistics published about the level of private-sector agricultural R&D investment in Australia. Unfortunately, the methodology used to collect this data and the different definitions used mean that the available data is questionable, and contradictory.

The Australian Bureau of Statistics (ABS) estimates of annual private-sector agricultural R&D expenditure in Australia range from $53.8 million to $412 million (depending on the definition and the categorisation used) although there is no information available to identify how much of this was net expenditure by firms, and how much was expenditure utilising funding from government or other sources.

The range of values arises because R&D investment can be categorised on the basis of:
- the principal activity of the organisation carrying out the research,
- the ‘field of science’ being used for the research, or
- the anticipated socio-economic outcomes of the research.

ABS survey respondents are required to self-assess and categorise their R&D expenditure, which is also a possible source of error in these statistics.

**Survey results**

A survey of firms that may potentially invest in agricultural R&D was carried out to gain a greater understanding of the scale and nature of private-sector agricultural R&D in Australia. A survey format was developed, and tested in ten face-to-face interviews during April and May, 2010, with research or development managers from major firms supplying farm inputs in Australia. The survey was then mailed to 281 firms in June 2010, which were contacted several times to encourage their participation. Responses were received from approximately 50 organisations, 31 of which were directly involved in agricultural R&D (with agriculture defined as including farm, forestry and fishery activities).

The gross R&D expenditure of all firms surveyed was $41.5 million, of which $32.2 million was ‘own-company’ expenditure, and $9.4 million was funding sourced externally. The average level of net R&D expenditure reported by firms participating in the survey for 2008–09 was $1.34 million. In excess of 93% of the R&D being carried out by the companies responding to the survey was classified as either ‘applied research’ or ‘experimental development’.

Survey respondents were allocated to broad groupings based on their main business activities, and the average R&D intensity was calculated. R&D intensity is a measure commonly used in analysis of trends in research and development expenditure at industry and national levels. It is calculated as the ratio of net own-firm R&D expenditure to gross sales revenue. As has been reported in similar international studies, there was a high degree of similarity in R&D intensities for firms within groups (see Table 1).

Survey participants were asked a series of questions about the activities of rural research and development corporations (RDCs). Their responses were generally quite positive, with firms that had previously collaborated with RDCs likely to be more positive towards RDCs than non-collaborating firms. When asked to rank the activities of rural RDCs on a scale ranging from complementary to competitive relative to their own activities, responding firms overwhelmingly saw the activities of the rural RDCs as complementary to their own R&D activities, rather than competitive. Firms that had previously collaborated with RDCs were more likely to see the RDC activities as complementary (see Figure 1).

Survey respondents were asked to score a range of factors that might either encourage or discourage investment by their firm in agricultural R&D in Australia. Figure 2 provides the combined results of that assessment.

The major factors encouraging R&D investment were the uniqueness of Australian agricultural systems (necessitating research under Australian conditions), the high rate of innovation adoption by Australian farmers, and the interaction between the public and private-sector R&D activities. The major factors discouraging private-sector R&D were regulations and costs and uncertainty associated with product registration processes (especially relative to the size of specific markets in Australia).

Based on research intensities for groups of businesses included in the survey, and extrapolating those research intensities for the whole market, it was projected that total
Net private-sector agricultural R&D expenditure in Australia in 2008–09 was approximately $197 million. Utilising that projection in association with other available data enabled a breakdown to be prepared of all the sources of agricultural R&D funding in Australia in 2008–09 (see Table 2).

Table 2 highlights that, depending on the definitions and the categorisation systems used, and whether revenue from compulsory farm R&D levies is counted as private-sector agricultural R&D or not, markedly different estimates arise of the share of total agricultural R&D that is funded by private-sector expenditure. The estimates of the share of private-sector R&D in total national agricultural R&D (35.5% excluding compulsory levy funds or 50.0% including compulsory levy funds) are much closer to OECD averages than previous estimates.

The Productivity Commission (Productivity Commission, 2011) in its recent report on future funding arrangements for rural R&D corporations found that total government funding for rural R&D in Australia in 2010 was $1,131 million, and as a result that the share of public funding of rural R&D in Australia was higher than indicated in Table 2.

In reaching this conclusion, the Productivity Commission utilised its own unique definition of what constitutes agricultural R&D, and included in its estimates public expenditure on:

- rural extension,
- capital works associated with research facilities, and
- environmental R&D.

in addition to activities that are normally defined as agricultural R&D. None of these additional activities are included in accepted international definitions of what constitutes agricultural R&D (for example as defined in the OECD Frascati Manual), and nor are they included in annual reporting of agricultural R&D expenditure by Australian government agencies, or in Australian reports on R&D funding provided for the OECD. It is unclear why the Productivity Commission used this much wider definition of agricultural R&D, which had the effect of increasing the apparent share of total agricultural R&D investment in Australia that is being funded by the public sector.

Irrespective of the levels of rural R&D funding in Australia contributed by the public and the private sector, it is likely that the private sector will become a more significant contributor in this area in the future, based on overseas trends. It is therefore in Australia’s interests to consider how best to encourage increased private sector investment in agricultural R&D in the future.

Conclusions

A conclusion from the research is that there is a range of initiatives that could assist in either better understanding the scale and nature of private-sector investment in agricultural R&D, or in encouraging increased private-sector R&D expenditure.

There is a need to implement a simple R&D data collection system that could be routinely utilised by public (and possibly private sector) organisations involved in agricultural R&D activities, and which could provide robust and useful information for policymakers and others in order to better understand agricultural R&D investment trends in Australia.

There is also a need to ensure that public-sector research organisations and RDCs have adequate expertise in R&D commercialisation and IP management. This would enhance cooperation between the public and private sectors, and provide an added incentive for private-sector R&D investment in Australia.

Arising from the survey and the review of literature, it is apparent that there are a number of initiatives that could provide further incentives to increase private-sector agricultural R&D investment in Australia. These include:

- improvements in laws protecting the ownership of IP
- the removal of restrictions on the development of GM crops and the rationalisation of GM crop R&D approval processes
- the continuing availability of the Australian R&D tax concession
- continuing and increasing investment by rural R&D corporations in agricultural R&D
- streamlining of chemical registration and approval processes to create greater certainty of outcomes and to ensure registration requirements are commensurate to risk.

References


Note: The Australian Farm Institute research report referred to in the above paper can be downloaded at www.farminstitute.org.au
## Appendix

### Table 1: R&D investment intensity by broad grouping

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Total R&amp;D investment intensity</th>
<th>Own-funds R&amp;D investment intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corporate farm businesses</td>
<td>1.76%</td>
<td>1.76%</td>
</tr>
<tr>
<td>Agricultural chemicals</td>
<td>1.98%</td>
<td>1.95%</td>
</tr>
<tr>
<td>Fertilisers</td>
<td>0.38%</td>
<td>0.14%</td>
</tr>
<tr>
<td>Forestry</td>
<td>4.59%</td>
<td>4.33%</td>
</tr>
<tr>
<td>High technology (animal/plant breeding and genetic technologies, computer and electronics)</td>
<td>15.6%</td>
<td>15.2%</td>
</tr>
</tbody>
</table>

Table 2. Source and amount of funding for Australian food and agriculture R&D, 2008–09

<table>
<thead>
<tr>
<th>Source of funding</th>
<th>$ millions</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>State governments</td>
<td>$254</td>
<td>Australian Government Department of Agriculture, Forestry and Fisheries annual data compilation for the OECD. Includes all state/territory governments recurrent expenditure on agricultural R&amp;D (excluding expenditure on rural extension), and capital expenditure on R&amp;D-related infrastructure.</td>
</tr>
<tr>
<td>Private-sector R&amp;D expenditure</td>
<td>$197</td>
<td>AFI Survey data. Data includes agri-chemicals, fertilisers, seed, fisheries and forestry and corporate farm businesses. Does not include food sector R&amp;D.</td>
</tr>
<tr>
<td>Food processing and manufacturing R&amp;D expenditure (private-sector)</td>
<td>$345</td>
<td>ABS 07/08 (8104.0) data for food processors and manufacturers business expenditures on R&amp;D.</td>
</tr>
<tr>
<td><strong>Total (including food sector)</strong></td>
<td><strong>$1538</strong></td>
<td><strong>Calculated from above data</strong></td>
</tr>
<tr>
<td><strong>Total (excluding food sector)</strong></td>
<td><strong>$1193</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Ratio of private-sector food and agricultural R&D expenditure to total R&D expenditure** 35% Calculated from above data. Funding from compulsory farm R&D levies not included as ‘private-sector expenditure’.

**Ratio of private-sector food and agricultural R&D expenditure to total R&D expenditure** 50% Calculated from above data, including funding from compulsory farm R&D levies as part of private-sector expenditure.

**Ratio of private-sector agricultural R&D expenditure to total R&D expenditure** 16.5% Calculated from above data (excludes food sector R&D expenditure, and excludes farm sector R&D levies).

**Ratio of private-sector agricultural R&D expenditure to total R&D expenditure** 35.5% Calculated from above data (excludes food sector R&D expenditure, and includes farm sector R&D levies).

*This amount does not include agricultural R&D funded by universities from general university funds. In total, this was estimated to be $1242 million in 2008–09. If some of this amount was allocated to agriculture in proportion with the number of agricultural students in total university student enrolments (1.5%), it would add $18.6 million to total public-sector expenditure.
Figure 1. Attitude of firms towards rural R&D corporations


Figure 2. Rating of factors encouraging or discouraging investment in agricultural R&D by private firms in Australia

Environment protection: challenges for future farming

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Abstract. There has been increased public demand for environment protection, including in rural areas. Government programs and policies have responded to these demands in various ways, such as by attempting to increase farmer awareness of environmental issues, increasing budgets for rural environmental programs, increasing environmental regulation, purchasing water from irrigators for environmental purposes, and encouraging farmer adoption of new environmentally friendly practices. These changes create a number of challenges for farmers, including challenges related to maintaining farm productivity, meeting community expectations, living with less water and evaluating new opportunities. These challenges are described and discussed. While there certainly are challenges, it is concluded that they are not insurmountable.

Keywords: environment, community expectations, water policy, carbon farming.

Introduction

As living standards rise, communities tend to place greater emphasis on environmental concerns. This trend appears to be playing out in Australia, at least over the long term. For example, public expenditure on environmental programs in rural areas has increased substantially since the 1980s. Public policy regarding land clearing has changed from it being encouraged (or even a requirement in some cases) to it being tightly constrained through regulation. New policies on climate change potentially have major implications for farming. This paper discusses changes such as these, with a focus on the challenges they are likely to pose for farmers in future.

Changes in public attitudes

Since the 1970s, Australians have developed stronger concerns for the environment. Environmental issues such as the proposed damming of Franklin and Gordon Rivers in Tasmania, salinity and climate change have been prominent in public debates over the past few decades. Australian Governments now spend hundreds of millions of dollars each year on environmental programs to satisfy voter expectations.

As well as changes in environmental attitudes, there have also been changes in the way that farming is viewed by the urban community. It is not many decades since the view of agriculture was predominantly positive: a provider of wealth for the country, a noble and highly respected job, our (then) strongest export industry. Most people had some connection to agriculture through friends, relatives or personal experience. These days, relatively few urban dwellers have any real connection to or understanding of agriculture, and urban sympathies for agriculture have declined substantially. Indeed, for many, their main perspectives on agriculture relate to its negative impacts on the environment or animal welfare. Farmers are less able to counter these views as agriculture becomes relatively less important socially and economically.

A consequence of the common lack of contact with agriculture is that many people have highly unrealistic expectations about what farmers can and should do to meet more stringent environmental standards. This lack of realism is not limited to public attitudes, but pervades national policy programs as well (Pannell et al. 2006), influencing the design of national programs such as the National Landcare Program, the Natural Heritage Trust, and the National Action Plan for Salinity and Water Quality (NAP). For example, over half of the project funds allocated under the NAP was spent on extension (Pannell and Roberts 2010), although, in most regions, the actions that were promoted were clearly not adoptable on the scale necessary to meet salinity targets (Pannell 2001).

To illustrate, Figure 1 shows the net economic benefits to farmers from increasing the area of lucerne (a key salinity mitigation option) in the Fitzgerald region of Western Australia. For a particular set of assumptions, it shows that lucerne can increase profit if
grown on up to 200 ha of this farm. However, containing salinity to reasonably low levels on the farm would require much larger areas of lucerne than this (e.g., Dawes et al. 2002). Figure 1 shows how lucerne becomes progressively more unprofitable as its area is increased above 200 ha. Indeed, at the time of this analysis, the potential to lose money through growing lucerne in this environment was much greater than the potential to make money. Notably, this is for a region where lucerne is considered to be relatively well suited and economically attractive. It is not surprising that program managers were disappointed with the extent of adoption achieved as a result of extension activities undertaken under the NAP (Pannell and Roberts 2010; Barr 2011).

Below, I will discuss several types of challenges for agriculture related to government environmental programs: the challenges of maintaining farm productivity, meeting community expectations, operating with less water, and assessing new opportunities.

**Maintaining farm productivity**

The first set of challenges relates to issues of land conservation that directly affect farm productivity. These include:

- Loss of soil structure (Howell 1987).
- Soil acidity (Dolling and Porter 1994).
- Water-repellency of some soils (Blackwell 1993).
- Waterlogging (Bligh et al. 1983).
- Wind erosion (Marsh and Carter 1983) and traffic hard-pans (Bowden and Jarvis 1985).

With these issues, a challenge for farmers is to find cost-effective management responses. As illustrated in Figure 1, and recognised more broadly (Pannell et al. 2006), some of the widely promoted management responses for these issues are too costly to farmers to be justified from a financial perspective, even over a long timeframe. The challenge is heightened because, when issues such as these primarily affect farm productivity, there is little justification for public funds to be used to offset their costs (Pannell 2008). The benefits of taking action are private, so the costs of taking action should be too. Some past environmental programs have not made this distinction clearly, and have provided financial support to farmers to undertake actions that mainly generate private benefits with few public benefits. It is hard to predict what may happen in future programs, but in the light of the trends in community attitudes outlined earlier, it seems possible that this may happen less frequently in future.

**Meeting community expectations**

Farmers have faced increasing expectations that they will manage their businesses in a way that does not cause degradation of environmental assets that are highly valued by the broader community. Issues in this category include:

- Degradation of remnant native vegetation (Hussey and Wallace 1993).
- Nutrient run-off or leaching causing downstream pollution problems (Waterhouse et al. 2010; Department of Natural Resources and Environment 2002).
- Greenhouse gases emissions, due primarily to livestock and burning of savanna and temperate grassland (FAO 2001).
- Loss of biodiversity. Among OECD countries, Australia has a relatively high percentage of threatened mammals and a high number of extinct or threatened plants. Land-use change for agriculture has caused nearly 90% of temperate woodlands and mallee to be cleared (Industry Commission 1998; Productivity Commission 2001).

In most cases, meeting community expectations for these issues results in a net financial cost to farmers. Indeed, in cases such as salinity, the costs to farmers of preventing all non-agricultural impacts would be so high (e.g., Dawes et al. 2002) as to render many farms non-viable. This is not to say that those farms should be sent out of business. One must consider whether the environmental benefits would be sufficient to justify the sacrifice of farm incomes and the social costs to farm families. For highly intractable problems like salinity, the answer to that question is often ‘no’, with off-site benefits from on-farm actions being very modest in many cases (Bathgate and Pannell 2001; Graham et al. 2010).

In past and current environmental programs, farmers have generally been asked to address these issues voluntarily, or with, at most, small temporary financial support. Notwithstanding that many farmers have made strong efforts to do the right thing, issues like salinity, nutrient pollution and loss of biodiversity remain serious concerns. It is not realistic to expect that farmers will voluntarily make the major financial sacrifices necessary to fully mitigate these threats.
The challenges of a purely voluntary approach have increased in some areas, where there has been an ongoing decline in the number of farmers and family members living in the landscape. For example, in the Western Australian wheatbelt, farms have continued to grow in size and shrink in numbers, such that there are fewer people available to undertake environmental projects, and those fewer people have greater demands on them, as they are responsible for larger areas of agricultural land than ever before.

**Dealing with future policies**

Looking ahead, several choices can be discerned for environmental policy makers: (a) continue with ‘business as usual’ and accept ongoing environmental degradation, (b) introduce regulation to require farmers to take environmental actions without compensation, (c) dramatically increase payments to farmers to compensate them for their costs in protecting the environment and thus to buy their cooperation, or (d) prioritise existing program funds more strategically so that a selected subset of environmental assets can be well protected.

While probably being unsatisfactory for all, ‘business as usual’ may turn out to be the most politically feasible option. A potential risk for farmers is that, as the failure of ‘business as usual’ to deliver desired environmental outcomes (Auditor General 2008; Pannell and Roberts 2010) becomes more apparent, community attitudes may harden, leading to demands for stronger environmental regulations. To some in the community, unaware of situations such as that depicted in Figure 1, regulation may appear a relatively cheap method for improving environmental outcomes. However, governments have shown themselves to be reluctant to rely on regulation as their front-line environmental policy in agriculture. Compared to, say, the mining industry, transaction costs of enforcing regulation over large numbers of small businesses are very high, and the technical feasibility of reducing some of the threats is perhaps lower. Information requirements for successful enforcement can be hard to meet. Political costs due to farmer outrage can be high. Even where regulations already exist, it is not uncommon for them to be left unenforced. In such cases, they serve only as a weak signal of community expectations. Overall, my judgment is that, while restrictions on clearing of native vegetation will remain in place, it is unlikely that farmers will face a substantial increase in regulatory approaches to environmental policy over the next decade or two. Mitigation of greenhouse gas emissions may be an exception, but even in this case, agriculture seems likely to receive special treatment relative to other sectors of the economy. Under current proposals, agriculture has the best of both worlds. It is not included within the emissions cap that would be imposed as part of the national emissions trading scheme, but it has opportunities to sequester carbon and sell offsets to businesses that are included.

The next possibility is a dramatic increase in funding for rural environmental programs. In my judgment, this also seems highly unlikely over the next decade or so. Community concerns about issues such as nutrient pollution and biodiversity loss do not seem to have increased over the past 20 years. With the exception of climate change, from a political perspective, the environment remains relevant but of secondary importance. The community’s environmental concerns are being closely focused on issues around climate change, arguably leading to neglect of other, perhaps more tractable, environmental issues. For these reasons, there is no sign of environmental budgets being greatly increased, outside the climate-change sphere.

The remaining option is to take a more targeted approach to spending public funds for the environment, carefully identifying projects for which it is most likely to be possible to generate large environmental benefits per dollar spent. I and other colleagues have been promoting this approach through tools like SIF3 (Ridley and Pannell 2005) and INFFER (Pannell et al. 2009). Although this comes up against some resistance to the idea that not all environmental problems can be solved, it is, in my judgment, the approach that will deliver the greatest environmental benefits given a limited budget. Under a targeted approach, there is a potential concern for farmers who have enjoyed participating in programs like Landcare and the Natural Heritage Trust. This is that only a minority of farmers would receive funding support: those for whom actions could best help to protect or enhance high-priority environmental assets. In reality, however, it is already the case that most farmers do not receive funding under the current national program, Caring for our Country. Further moves in this direction would be a matter of degree, rather than a fundamental change. In my view, adopting a more business-like approach to the selection of environmental projects, and demonstrating meaningful outcomes from past investments, are essential if proposals for increasing the budget for these sorts of programs are to win sufficient support.

especially from influential treasury and finance departments.

**Operating with less water**

Perhaps the most contentious issue in Australian agriculture in recent years has been the plan by the Murray-Darling Basin Authority (MDBA) to purchase water from irrigators, in order to benefit the environment. In fact, governments had been buying water on the open market for some time prior to the issue becoming contentious. The trigger for dramatically increased public concern was the release in 2010 of a ‘Guide’ to a new Plan by the MDBA, spelling out how much additional water they intended to purchase in coming years.

The strategy of the plan was to buy water only from willing sellers, so from a business point of view, the main challenge facing irrigation farmers would be deciding whether they wish to sell their water at the going price. It appears that there were two elements to the controversy: (a) a misunderstanding by some farmers about the voluntary nature of the program (or perhaps mistrust that it would remain voluntary), and (b) concerns about perceived social impacts, especially losses of jobs in rural areas. A number of economic modelling studies concluded that, in the long run, impacts of the Plan on employment would be minor – of the order of 1000 jobs lost. However, members of the community in the basin found this implausible, given the large volumes of water that would be diverted to environmental uses. It was also acknowledged by economists that the impacts could be large in certain local areas.

The political controversy led to a partial back-down by the Australian Government. The final level of water to be purchased is not yet determined, but appears certain to be significantly less than the minimum level specified in the original Guide.

This episode highlights the tension between the business and social priorities of farmers and city dwellers who are concerned about the environment. Of course, many rural people care about the environment as well, but this issue was often portrayed by protesters as an us-versus-them, rural-versus-city issue. Indeed, given the contrast between the voluntary nature of the plan and the strength of protests that it caused, it may be that the protests were largely a reflection of broader rural-urban tensions, rather than being primarily about the Plan itself. Perhaps this is a sign of things to come. Perhaps there will be increasing political demands for water for environmental purposes, as well as increasing resistance and militancy by rural residents concerned about local social impacts.

Irrigation farmers who face the need to cope with reduced water availability, face the challenge of how best to adapt their management practices and land uses. They may need to keep up with water-conserving innovations, requiring time, effort and expense, but hopefully resulting in economic benefits to the farm business.

**Assessing new opportunities**

The final group of challenges relates to the difficulties farmers may have in assessing new farming practices or systems that are promoted to them as suitable responses to environmental problems. There are not usually great difficulties in adopting new practices that are similar to existing farm practices, such as a new variety of a familiar crop. However, some environmental practices are quite novel, and so have additional learning requirements. Their novelty may make it relatively difficult to learn by observation, slowing down the process of decision making (Pannell 2001; Pannell et al. 2006).

In the current context, a standout example where it may be difficult for farmers to assess new opportunities is soil carbon sequestration. Under the Australian Government’s Carbon Farming Initiative (CFI), farmers are to be paid for adopting practices that lead to increased levels of sequestration of CO₂, including in agricultural soils. The practices that may increase sequestration are likely to be relatively familiar to farmers, such as changes in land uses and stubble retention. However, participation in the CFI itself involves complexities and uncertainties that create difficulties for farmers, including:

- Uncertainty about which practices will be considered to be ‘additional’ under the scheme, thus qualifying for payments. An effective way to increase sequestration of carbon in agricultural soils is to practise stubble retention. However, stubble retention is already considered to be good agricultural practice, and has been widely adopted, particularly in some regions (Llewellyn and D’Emden 2010). According to the rules and principles that underpin the scheme’s design, this would likely rule out stubble retention as a valid activity for claiming credits, although it is not completely clear at this point whether it will be included in the scheme.

- Opportunity costs from changing land use. If stubble retention is not covered by the scheme due to lack of ‘additionality’, the main farming practices that would increase sequestration are changes in
land use, such as switching from cereal cropping to perennial pastures. However, this involves opportunity costs for farmers – they must give up the income from cropping for a smaller income from perennial pasture. Whether payments under the CFI scheme are sufficient to outweigh this reduction in income requires difficult judgements and calculations. For the case of the Western Australian wheatbelt, an analysis by Kragt et al. (2011) indicates that the opportunity costs are likely to outweigh the benefits from payments under the CFI, unless the price of offset credits reaches much higher levels than the initially proposed carbon price under the Carbon Tax scheme. It is unclear what the future trajectory of prices will be, beyond the first few years.

- Leakage. Switching land-use from cropping to perennial pastures would probably involve an increase in livestock numbers on the farm. However, this would result in an increase in emissions of methane, another greenhouse gas, resulting in a reduction in net benefits under the scheme. In some cases, leakage may be large enough to outweigh the benefits of increased sequestration. In principle, such leakage should be deducted from any sequestration estimates used to determine offset credits, although whether this will actually occur remains to be seen.

- Uncertainty about the levels of CO₂ sequestration attributable to different practices. There is some disparity between the likely levels of sequestration claimed by some enthusiastic farmer groups and the peer-reviewed scientific evidence. Whatever the correct average level of sequestration is, levels are likely to vary considerably from region to region, from time to time, and from soil type to soil type.

- Permanence – the need to commit to changes in the long term. A feature of the CFI is the requirement for participating farmers to maintain any credited sequestration for 100 years beyond the last date for which they receive payments under the scheme. This creates considerable costs and uncertainties for farmers. Over such a long time frame, there are likely to be major changes in agricultural technologies and prices of agricultural commodities. A commitment to the CFI currently may exclude farmers from substantial future benefits that cannot currently be foreseen. In other words, there is likely to be a significant ‘option value’ from not joining the scheme and waiting to see what happens to technologies and prices.

Clearly, the complexities and uncertainties of participation in the CFI scheme will create challenges for farmers. It will require considerable effort on their part to learn about the scheme, and even then it may be difficult to judge whether the benefits of participation outweigh the costs.

A less extreme example of difficulty in assessing a new option is the potential adoption of novel land uses that are different to traditional crops and pastures. For example, the Future Farm Industries CRC is developing and promoting new perennial-based farming systems, including novel pastures, shrubs and trees. It is these more novel land uses that are likely to be needed for major improvements in environmental conditions. However, even without the complexities of a scheme like the CFI, the learning and trialling process for these new farming options is more challenging than for new options that are relatively minor variations on established land uses, such as new crop varieties.

**Conclusion**

Environmental issues associated with agriculture have increased in prominence in recent decades. Government programs to address these issues are now on a much larger scale than they were prior to the 1990s, reflecting increased expectations by the community that there should be reductions in environmental degradation in rural areas. Nevertheless, the budgets available under schemes like the Natural Heritage Trust and Caring for our Country remain very small indeed compared to costs that would need to be incurred to manage environmental degradation comprehensively. Thus one of the key challenges for agricultural industries in coming decades will be meeting community expectations in relation to the environment. It is unlikely that these expectations will be met with current approaches to environmental policy. In particular, a reliance on farmers making voluntary changes, with or without small temporary grants, is unlikely to turn around salinity, biodiversity loss and nutrient pollution in waterways in most cases where these problems are serious. I have argued that two of the possible policy responses to this situation, increased use of regulation, and dramatically increased program budgets, are both unlikely to occur. If that is true, it leaves policy makers with a choice between a business-as-usual approach, and more strategically targeted use of the available resources. The latter inevitably means that fewer farmers would receive funding support.
for their environmental actions, but is more likely to deliver significant environmental outcomes in the long term.

The recent controversy related to purchase from irrigators of water for the environment was discussed. I argued that this was primarily about social issues, rather than impacts on farm businesses. Indeed, the community’s political success in scaling down the planned purchases of water will come at a cost to individual farmers who would have benefited from being able to sell their water at higher prices.

Finally, farmers face challenges in evaluating some of the farming practices that are promoted to them within environmental programs. This was illustrated by the example of the Carbon Farming Initiative, which involves considerable complexities and uncertainties for farmers.

Overall, it appears that the challenges discussed here are not insurmountable. They may add to the difficulties of farm management, but seem unlikely to have devastating impacts on many farm businesses.

Acknowledgments

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Appendix

Figure 1. Marginal value of increasing lucerne area in Fitzgerald region of Western Australia. Source: Bathgate and Pannell (2002)
Towards a more nuanced discussion of the net-benefits of sharing water in the Murray-Darling Basin

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Abstract. Despite the focus by stakeholders, the States and the Murray-Darling Basin Authority on exploring the economic costs and benefits of the proposed Murray-Darling Basin Plan, there are a number of issues relevant to an economic evaluation of the Plan that are easily overlooked. While a proposed Murray-Darling Basin plan has been released, water sharing agreements will continue to evolve and much detail remains to be worked out as part of implementation at the state level. Given this, we seek to synthesise current research on the costs and benefits of the Murray-Darling Basin plan. In doing so we discuss eight issues relevant to understanding the net-benefits of water reforms that, though recognised in the literature and policy debates, have become somewhat peripheral despite their potential importance. The first two issues are related to the potential social costs associated with reduced viability of communities and ongoing viability issues for farms. The next three issues are focused on benefits from the proposed Plan. This includes the estimation of benefits for downstream beneficiaries, the opportunity provided to farmers from selling water and the benefits associated with reductions in system risk due to non-incremental changes in ecosystems. The remaining three issues relate to approaches for maximising the benefits associated with the water reform process. This includes the evaluation of a wider range of options, consideration of how to better use water markets to assist farmers to manage risk, and evaluating not only how much water is needed but how it can be more effectively managed.

Key words: irrigation, environmental benefits, water buy-backs.

Introduction

In October 2010, the Murray-Darling Basin Authority (MDBA) released a Guide to the proposed Basin Plan and held a series of information sessions with communities and the States in the Murray-Darling Basin (MBDA 2010). Major newspapers reported that the Guide to the proposed Plan was met by immediate opposition from communities within the Murray-Darling Basin (Wahlquist 2011). People in communities were concerned about the potential loss of jobs and impacts on local communities. Subsequently, many of the concerns of affected communities have been captured in an extended set of reports released in January 2011 (EBC et al. 2011). On November 28, 2011, a proposed Basin Plan was released for consultation. A window of opportunity exists for a more nuanced public discussion about the benefits and costs of resetting the balance among water users. State water resource plans are to be developed and accredited by 2014 in New South Wales, Queensland and South Australia and by 2019 in Victoria. Considerable detail remains to be worked out at the State level through the development of Water Plans, the implementation of these plans as well as the next ten-year plan. Thus the proposed plan will not be the final word on how water will be shared among water users in the Murray-Darling Basin. The debate about the costs and benefits of the proposed Murray-Darling Basin Plan has been framed by the requirements of the Water Act 2007 [sec. 20d]. The Water Act 2007 sets out the requirement to limit extraction quantities of surface and ground water resources to environmentally sustainable extraction levels. Further, according to the wording of the Act, water resources are to be managed in a way that optimises economic, social and environmental outcomes. In addition, the Plan is to be evaluated using best available science and economics. For the majority of economists, this implies that cost-benefit analysis will be used. However, cost-benefit analysis is only a decision support tool. There are choices about how to define the alternatives to be evaluated and the assumptions to be used; all of which influence costs and benefits to be considered and how are they estimated.

In this paper we therefore seek to review and synthesise what is already known about the economic costs and benefits and then discuss eight other issues germane to considering the full range of costs and benefits associated with addressing over-allocation.

Estimation of the costs of the proposed Murray-Darling Basin Plan

To estimate the costs of the proposed Murray-Darling Basin Plan, various computable general equilibrium (CGE) models have been used to derive estimates.
of losses in production, producer surplus and employment that could follow from reduced water for irrigated agriculture under the scenarios provided in the Guide to the Basin Plan. This includes models developed by researchers at the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), the Australian National University (ANU), the Centre of Policy Studies (CoPS) at Monash University and the Risk and Sustainability Management Group at the University of Queensland. Water management is typically modelled by combining hydrologic models of water availability and flow with long-term economic models of the regional economy.

Modelling by ABARE-BRS (2010) estimated that reductions in surface water diversions of between 3000 and 4000 GL/year by irrigated agriculture result in: (i) a fall in the gross value of irrigated agriculture of 13-17 per cent; (ii) a lowering of irrigated agricultural profits of between 6-9 per cent; and (iii) a decline in Basin employment of between 0.09-0.12 per cent. Similar magnitude economic impacts were reported by Mallawaarachchi et al. (2010) from the University of Queensland who suggested that the gross value of irrigated agriculture would fall by 16 per cent.

Goesch et al. (2011) (from ABARES) subsequently modelled the effects of a 3500 GL reallocation of water from irrigation to the environment. They estimated that the gross value of irrigated agricultural production would decline by 15% without any mitigating policies, and 10% if mitigating policies were used (e.g., buy-backs and investment in irrigation infrastructure). In terms of overall agricultural production, this would fall by 5% without use of mitigating policies, and 4% if they were applied. In the long run they estimated that Basin employment would decrease by about 900 jobs in the absence of mitigating policies, and remain virtually unchanged if mitigating policies are used. However, short-run employment effects could be more significant. In order to provide a polar extreme estimate of the potential impacts in the short run, Goesch et al. (2011) estimated that short-run employment effects in the absence of any mitigating policies and assuming that all water was sourced at one point in time (neither of which are proposed), water buy-back could lead to 5000 job losses.

Grafton and Jiang (2011) from the ANU, estimated that the resulting reduction in annual net Basin returns, was 9.5 per cent for a reduction in irrigation of 30 per cent and 16.3 per cent for a 40 per cent reduction in use of water for irrigation. Their model showed that foregone profits resulting from additional environmental flows may be modest with a free water market. However, particular regions may be more vulnerable than the average (e.g., the Murrumbidgee).

Dixon et al. (2011) at CoPS used their regional general equilibrium model “The Enormous Regional Model (TERM – H2O)” to analyse the effects of government water buy-backs and find that under their assumptions, economic activity in the southern Murray-Darling Basin would increase. Wittwer (2011) further analysed the question of the relative impact of water buy-backs and drought in the MDB. He found that the short and long-term employment impact is many-fold greater under drought conditions as compared to water buy-backs. For example, he forecast 6000 job losses across the Basin because of drought, but only 500 jobs lost when buy-backs are modelled (or 800 jobs lost if water use was restricted but no compensation was paid through water buy backs).

Overall, the results of these analyses suggest that a reallocation of between 3000 to 4000 GL may reduce irrigated agricultural output by about 10-17% depending on the assumptions made and the model used. Overall agricultural output is estimated to decline by less than this for irrigated agriculture because it is estimated that resources would shift out of irrigated agriculture to dryland agriculture. Employment effects across the Basin are likely to be negligible in the long run given the reallocation of labour resources over time to dryland agriculture and to other sectors within and outside of the Basin as well as because of the methods that the government plans to use to obtain water (Dixon et al., 2011). However, in the short run, job losses, potentially significant, are likely to be experienced in various irrigation communities within the Basin (EBC et al. 2011).

The studies described in this section have all involved impact assessments. Jiang (2011) provides an overview of some of the modelling challenges associated with such assessments. In addition, when assessing costs they have focused on identifying likely decreases in agricultural output, profit and employment. One limitation of this is that none of these measures is directly relevant for cost-benefit analysis, which measures costs in terms of decreases in producer and consumer surplus. A second limitation is that analysis of this type may exclude some costs of concern to the wider community, such as impacts on the viability of communities or farms, which are two issues we discuss shortly.
Estimation of the benefits of the proposed Murray-Darling Basin Plan

On the benefits side, there have been many studies undertaken over the last 20 years to estimate the value of improvements in riverine and wetland health in the Murray-Darling Basin. The studies focus on the value of particular wetlands and rivers across the Basin creating snapshots of the value of recreation and tourism as well as the intrinsic value of the environment. These studies have used a diversity of methods such as hedonic pricing models, travel cost models, contingent valuation and choice modelling (summarised in Hatton MacDonald et al. 2011a). Many of the studies are quite local or regional in nature. Hatton MacDonald et al. (2011b) present national estimates of willingness to pay to improve the River Murray and the Coorong.

As a summary of the benefits of the proposed Basin Plan, Morrison and Hatton MacDonald (2010) developed an inventory of existing studies valuing improved river health. They produced estimates for each catchment in the Basin of the value associated with increased recreational activities, as well as values associated with improving vegetation, native fish populations, frequency of waterbird breeding, and waterbird species found in important wetland areas. Morrison and Hatton MacDonald (2010) did not seek to produce aggregate benefit estimates, but rather per unit value estimates that could be combined with ecological response functions to identify the values associated with specific Sustainable Diversion Limits (SDLs).11 A summary of the value estimates produced from this study are presented.

The body of existing work, undertaken for a variety of purposes, was however limited in its ability to evaluate the benefits of the proposed Basin Plan. None of the original studies covered the proposed scope contemplated in the Guide to the MDB Plan of 3000 to 4000 GL (CIE 2011). Of particular concern was the challenge associated with adding up the non-use values across each of the individual catchments (Morrison and Hatton MacDonald 2010), as well as paucity of research on recreation values and other indirect use/ecosystem service values.

The task of understanding benefits is complicated by the fact that ecological response models for the entire basin are not currently available, many of the improvements in ecology will be realised in the medium to long term, and are dependent on how the States implement their Water Resource Sharing Plans as well as on other natural resource management policies. Additionally, there are many ways volumes of water reallocated to the environment can be delivered with resultant ecological responses. Interdisciplinary work which forges stronger links between the hydrology, ecological responses, and socioeconomic benefits will be fundamental in the next stage, once the Plan is operational. An important challenge will be to optimise the multiple objectives of the Basin Plan – social, economic, and ecological – and any tradeoffs (e.g., between upstream and downstream ecological assets) that this implies.

As part of this process, there are potentially several other benefits of relevance to evaluating the Murray-Darling Basin Plan that have received relatively limited attention. These include understanding the increase in downstream production values from a reallocation, the benefits to irrigators from the sale of water with low reliabilities, and the values associated with reduced system risk, and are discussed in the next section.

Other potential costs, other potential benefits and other potential options for maximising net-benefits

Due to the nature of impact assessment and the way that environmental valuation is typically undertaken, there is a tendency to focus on certain costs and benefits when undertaking cost-benefit analysis. It is possible that certain cost and benefit items, that while noted in the literature, become somewhat peripheral and possibly excluded. Further, it is possible that certain opportunities for maximising net-benefits associated with water reforms may also become peripheral, because they are not part of the purview of the Water Act. Nonetheless, they may be relevant to the wider societal goal of maximising social welfare through the water reform process. Hence, in this section we discuss eight issues that we believe are of relevance to maximising the net-benefits associated with the water reform process. These issues have for the most part previously been identified in the literature, yet have become somewhat peripheral in the public debate.

Other potential costs

Issue 1: What is affecting the viability of communities?

Of particular concern to communities negatively affected by the proposed Murray-Darling Basin Plan has been the potential

11 SDLs are the maximum long-term annual average quantities of water that can be taken on a sustainable basis from the Basin’s total water resources and from each area. If exceeded, the extraction could compromise: key environmental assets/functions/outcomes of the water resource; and the productive base of the water resource (MDBA 2010).
effect on population levels and cultural identity. Communities have also been concerned about the closure of farm related and non-farm related businesses, changes in demographics and effects on mental health (EBC et al., 2011). This is of relevance to cost-benefit analysis as previous studies have demonstrated that there may be non-use values associated with preventing decline of rural communities (e.g., Bennett et al. 2004). Without disputing the legitimacy of these concerns, agriculture is an inherently uncertain enterprise. Farmers have always faced uncertainty over weather from drought to flooding as well as long-term structural agricultural change. Long-term pressures that have transformed farming include the liberalisation of trade conditions in Australia, and the decline in terms of trade over time, which has resulted in an increasing pressure on farmers to make their enterprises more productive (McColl and Young 2006; Barr 2009). Commodity prices can fluctuate markedly within relatively short spans of time and changes in currency exchange rates and consumer preferences can quickly displace what were previously secure farm markets. As farmers are generally price-takers, they do not have the opportunity to influence demand. Hence to maintain an equal return on their investment they need to increase their output, and have done so over time by increasing farm size (Barr 2009).

As a consequence the trend has been in the Murray-Darling Basin (and across Australia and the world) towards fewer farms of bigger size. The number of farms in Australian agriculture has declined by 1.3% per annum over the past few decades (Barr 2009). In real terms, this has led to a reduction of almost 32,000 family farms; a drop of 22% between 1986 and 2001 (Australian Bureau of Statistics 2003). These changes also imply a greater degree of diversity within the sector. There are more large enterprises. For example, between 1994 and 2004, the number of farm enterprises worth between $1m and $2m almost doubled. The number of low value farms (up to $22,500) reduced by approximately a third (Barr 2009). Barr (2009) found there were higher than average exit rates in peri-urban areas and in irrigation districts, particularly where dairying was a major industry. In peri-urban areas, demand for land is driving land prices up, providing farmers an incentive to sell.

One view is that fewer family farms leads to general de-population in rural areas, making it harder for rural communities to maintain an adequate employment base and to provide the range of goods and services desired by residents (Barclay et al. 2007). Less buoyant rural economies provide fewer off-farm employment opportunities and this can have detrimental consequences for family farms, where frequently the farm income is just one source of household income (Barr 2009).

One potential reason for de-population is that younger people have more attractive educational opportunities and greater off-farm work opportunities (Barr 2009). In Australia, as in many other parts of the world, the agricultural workforce is ageing and fewer young farmers are entering the industry. The median age of Australia's farmers has been climbing since 1976. In the 2001 Australian Census, 15% of farmers in farm families were aged 65 years and over, whereas those under 35 years accounted for 12% of farmers (ABS 2003). Wheeler et al. (2011) found the mean age of irrigation farmers in Australia's largest irrigation area, the Goulburn Murray Irrigation District in Victoria, has risen over the past decade, from 49 years of age in the late 1990s to 56 years in 2010-11.

Declines in population may also be due in part to a myriad set of factors from commodity price changes, declining health and education services, uncertainty related to climate change and water allocations through to succession planning (Wheeler et al. 2011). In their study of influences of changing farm succession over time, Wheeler et al. (2011) found that naming a successor was positively associated with the current and future management of farms, as farms who had not named an heir were more likely to go into a period of stagnation (selling land, not adopting efficient irrigation infrastructure, not increasing irrigation area). Farms that named a successor were more likely to be positively adapting to changing circumstances than farms with no successor. Also, when analysing succession across districts, they found that it was more influenced by characteristics of irrigation districts than actual farm types.

Overall these results suggest declining rural population trends are likely to continue regardless of the implementation of the proposed Murray-Darling Basin Plan, and hence any estimation of the non-use values associated with decline in the communities associated with the Basin Plan should recognise this trend. Long-term structural changes in agricultural areas, ageing of the farming population due to younger people having more attractive options elsewhere, and uncertainty related to climate change will all occur, even if the Plan were not implemented. However, it is likely that uncertainty with respect to water allocations remains a contributing factor to depopulation. Future research must consider in more detail
this question. In particular, we need to understand how changes in government water and agricultural policies play a part in regional farm exit choices over time, taking into consideration other key influences on such as differences in water allocations, climate conditions and regional water market conditions. One key question that should be studied is how much current government policies and programmes have influenced the ongoing adjustment process that would have occurred anyway without the buybacks.

**Issue 2: Does selling water provide farmers with an opportunity to retire comfortably or does it have consequences for the next generation?**

As noted, the average age of irrigation farmers is increasing. Two of the reasons for this are the reluctance of older farmers to retire, and the inability of the farm to support two generations (Wheeler et al. 2011). The unbundling of land and water (i.e., the legal separation of land and water rights) reforms and the increased opportunities to sell water entitlements has meant that it has allowed some irrigators to sell their permanent water, provide for their retirement, and pass the farm onto the new generation (based on qualitative research underpinning Wheeler et al. 2012). The increased value of water licences, due at least in part to water buybacks, has meant that the retirements of those farmers selling water for this purpose is more comfortable than it would otherwise have been. Whether this benefit is included in a cost-benefit analysis depends on whether the analysis is undertaken from the standpoint of the nation or the region. For the nation, the water-buy-backs are essentially the sale of property and would not be included in a cost-benefit analysis. On a regional level, there may be a net benefit after tax.

While buybacks have clear advantages for those seeking to retire, there are consequences for those receiving properties without water as inheritances. The younger generation faces a more difficult transition period with reduced or no ownership of water entitlements. They have to either manage the farm as a dryland property or buy in temporary water (the viability of which is determined by rainfall and storage). However, some properties that are a viable size with irrigation may not be a viable size as dryland properties (nor may be appropriate to be farmed as a dryland property). This implies that these properties may need to be sold and consolidated with other properties. It is possible that this may lead to a further decrease in rural employment and impacts on regional communities, and hence costs, though empirical analysis would be needed to assess how farm viability is going to be affected by buybacks, and an assessment made of where this is likely to be a concern.

**Other potential benefits**

Next, three other potential benefit items of relevance to economic evaluation of the Basin Plan are discussed.

**Issue 3: Increasing uncertainty of general security licences because of climate change**

Climate change implies a shifting of rainfall patterns in the Murray-Darling Basin, with less rainfall expected in the southern Murray-Darling Basin, the major source of basin flows (CSIRO 2008). This would be expected to lead to a reduction in water supply reliability, especially for lower reliability licences. Table 2 highlights the water allocations that have been received in various districts over the past decade. It shows the difference been high and lower reliability entitlements. During the height of the last drought, in Victoria and in New South Wales, lower reliability entitlements have received low allocations.

The future advent of climate change means that those holding lower security (and in some states – even high security) licences are likely to face higher risk in relation to their farm-level water plans. This risk will be greatest for permanent crop irrigators or those that need to make decisions before the water season starts or allocation levels are announced. Lower reliability may influence the desirability of holding general security licences, and potentially their value. As evidence of this point, Wheeler et al. (2012) found that those selling water to the government, or are likely to do so in the future, are more likely to be in regions that have experienced severe cuts in water allocations over the last five years. Therefore, the Commonwealth’s program to buy back water, the *Restoring the Balance* program, has potentially provided a means for many to sell these riskier licences. Farm communities will therefore benefit from farmers being able to sell problematic assets, reduce debt or invest in other ways on or off their properties as a large proportion of those selling water indicate that they intend to do (Walpole et al. 2010, Wheeler et al. 2012). It is possible that this may lead to some farm families being able to remain on their properties, which may not have been possible if they had not been able to sell their water. This would therefore enhance rural communities, and create a positive non-use value. However, further empirical research on farm exit over time would be needed to identify the extent of this benefit.
**Issue 4: Recognise downstream non-environmental beneficiaries**

The debate about the benefits and costs of the proposed Murray-Darling Basin Plan has often been framed as involving costs to irrigators and benefits to the environment. The distribution of costs and benefits is more complex than this.

The proposed Water Sharing Basin Plan makes provision of water for critical human needs a key priority. The city of Adelaide and other country towns at the bottom of this river system depend in large part on water from the Murray-Darling Basin (see Figure 1). Increased environmental flows can have a number of benefits to downstream communities in terms of reduced treatment costs, reductions in risks associated with cryptosporidium and avoided salinity-related damage to infrastructure.

Increased flows to the southern part of the Murray-Darling Basin, in particular, to the Lower Lakes in South Australia, will also benefit irrigators in these areas. There was a substantial contraction in irrigation due to increased salinity levels in the Lower Lakes during the Millennium Drought (2001-2010). Salinity levels have been subsequently decreased with the increased rainfall/flooding through 2010-11. Flows which meet the environmental water requirements for some of the major downstream assets will also benefit some downstream irrigators.

Historically, there have also been substantial communities of wetlands graziers in major wetland areas such as the Macquarie Marshes, Gwydir Wetlands, the Paroo and other wetland areas, (see Figure 1). These areas were known to provide high quality feed, and to be relatively drought resistant, with many farmers sending stock there during droughts. The development of irrigation areas during the 1970s and 1980s heralded a substantial decline in grazing and farmer populations in these areas.

Nonetheless, the value of grazing in these wetland areas is recognized in the literature, and might be expected to increase with any reallocation of water to environmental uses. For example, Arche Consulting (2010) recently found that flooding increasing gross profits of graziers by 59% and that there is an annual increase in profitability of $12.50 per hectare for floodplain country. Other earlier studies of wetlands grazing have also demonstrated the value of this beneficial flooding (Cunningham 1997). It is arguably appropriate that the magnitude of these benefits be identified in any economic analysis undertaken of the proposed Murray-Darling Basin Plan.

**Issue 5: The value of reduced system risk**

There has been a tendency when discussing the ecological benefits associated with the proposed Murray-Darling Basin Plan for economists in particular to treat the outcomes solely in marginal terms. This is the standard framework in economic analysis where a question typically posed by an economist to an ecologist is "How much will the population of X increase given water regime Y". There are several limitations with this approach. One limitation is that the predicted outcomes are generally stochastic and subject to uncertainty.

A second less obvious limitation is that the marginal improvement in ecological quality is not the only benefit from the proposed Plan. The reallocation will also reduce the risk of catastrophic ecological collapse (Quiggin 2008), such as substantial declines in the populations of significant species, or other non-incremental changes in ecological systems, which may not just have consequences for the environment, but for agriculture and humans as well. This is of particular concern given the ecological challenges posed by climate change. Many of the long-term changes to adjust the Basin Water Sharing Plan in response to climate change have been deferred to the next 10-year plan (Quiggin 2011). This provides an opportunity for research that forges stronger economic-ecological understanding and follow-on policies to manage for the risk of system collapse.

**Other options for maximising net-benefits**

**Issue 6: An opportunity to evaluate other options**

In cost-benefit analysis it is desirable to evaluate a range of options to identify those alternatives which have the highest net-benefit. In the evaluation of alternatives for the proposed Murray-Darling Plan attention has been focused primarily on alternatives involving reallocation of about 3000-4000 GL or less. The alternatives considered the use of water buy-backs and infrastructure investments to produce the necessary water savings.

There are several alternatives that could be considered in the next series of evaluations. This includes alternatives that involve much smaller reallocations of water (e.g., 1500 GL) and those that involve much larger reallocations of water (e.g., 4500 – 6000 GL). It is possible that some of the ecological outcomes that might be achieved through water reallocations are subject to key ecological thresholds that require larger reallocations. A cost-benefit analysis with a
wider purview would allow this to be assessed (see also Frontier Economics 2011). These are, however, not the only alternatives that might be considered in a more wide-ranging cost-benefit analysis. Because the fundamental goal of the Plan is to improve environmental quality, this raises the question of whether only focusing on purchasing permanent water is the best way to do this. Environmental improvements might be achieved by purchasing less water but investing more money in achieving other environmental outcomes such as buying up properties in ecologically sensitive areas (see Crossman et al. 2010, Byron 2011 and Pittock and Finlayson 2011). Others have raised the need for the Commonwealth Environmental Water Holder to engage in temporary trade: both the buying and selling of water allocations (Productivity Commission 2010).

A final alternative that is worthy of consideration is an alternative that changes the way that buy-backs are operationalised. Currently the water buy-backs are by tender and allow all landholders to offer their water for sale. While this approach provides equality of opportunity to all irrigators, some costs are faced by those who do not sell water if there is a hollowing out of the local economy and community. There may also be other impacts from reducing the number of landholders servicing the infrastructure in irrigation districts. An alternative is to consider purchasing water at a district farm level rather than an individual level. This would see buy-backs favoured in an area where a group of landholders want to sell water, rather than only a few individuals. This would mean that in areas of buy-back the benefits are more uniformly shared, and there is likely to be greater support for the buy-back in the local community. Prioritising of districts for buy-backs could also be based on what makes sense from an agricultural perspective. For example, one logical choice would be where there are areas of marginal farm viability or poor irrigation off-farm infrastructure and hence consolidation of properties is likely to be needed in the future regardless of the buy-backs. Indeed, the Federal Government has just committed to only strategic water entitlement purchasing in 2012; favouring a series of rolling tenders and greater emphasis on investment in infrastructure upgrades and water saving projects (Burke 2011).

**Issue 7: The need to modify water markets to reduce risk**

Given the inherent risk associated with farming, and the prospect of further adverse climate change in the Murray-Darling Basin, there is greater scope for farmers to continue to develop using the water market as a risk management strategy. The ability to carry-over water from one year to another is a valuable risk management strategy for many irrigators; however, the inconsistency of rules across states and various suspensions of carry-over provisions make risk planning increasingly difficult (Loch et al. 2012). Given other uncertainties facing farmers, expanding the carry-over provisions could help in reducing risk (Young 2011). With attention to institutional design and how to make water markets more efficient, the effectiveness of this risk management strategy for farmers could be enhanced. Research that focuses on institutional design of caps, embargos, support payments, and carry-over strategies could provide substantial benefits to irrigators over the long term, and hence we believe should be prioritised as an approach for increasing the benefits associated with water reforms.

**Issue 8: Management of water as well as increased allocation**

Through the implementation stages of the Basin Plan and development of State water plans there will be an opportunity to consider the management of water entitlements rather than just a focus on obtaining a certain amount of water as a way of maximising the benefits associated with the water reform process. Crase et al. (2011) argued that the current focus on entitlement volume ignores the complexity involved with environmental water management and the non-linearity between volume and environmental outcomes. As of October 2011, the Commonwealth Environmental Water Holder has purchased over 1,000 GL of water MDBA (2011). With its current water holdings, the Commonwealth Environmental Water Holder will need to manage entitlements on behalf of the environment and might benefit from trading in temporary water and derivative water products. The Productivity Commission (2010) has also advocated the need for portfolio approaches coupling allocation trade with entitlement purchasing, and argued that derivative water products such as long-term leases, option contracts and water use covenants could be highly beneficial.

**Summary**

By highlighting a series of eight issues that, while raised in the literature appear to have had limited attention, it is hoped that we identify opportunities for improving economic analyses associated with on-going water reform and implementation. On-going research by academics, the Murray-Darling Basin Authority and other government agencies will be helpful to optimise outcomes
from water reform. The Murray-Darling Basin Plan is one step in a sequence of State and Commonwealth processes. Ultimately much will depend on the implementation through State-level water plans. Nonetheless, there remain opportunities to utilise further research to capitalise on potential benefits to society.

In evaluating the costs of the proposed Plan, attention has focused not just on the costs to agriculture but also the impact on Basin communities (EBC et al. 2011). This is potentially relevant from an economic perspective if there are non-use values associated with declines in regional communities. The issue is, however, more complicated than a simple loss of jobs or decline in regional economic activity. Decline in the viability of agricultural-dependent communities has been occurring for decades due to a number of factors unrelated to environmental management, such as drought, commodity prices, strength of currencies and international trade rules. While the proposed Basin Plan will have some impact on a number of communities, it is important to keep in mind that it is part of an ongoing rural structural adjustment process. Over the past decade, the reliability of different types of water licences has fallen considerably, increasing uncertainty for many irrigators, and buy-backs provide some irrigators with an opportunity to exit irrigation. It also provides others with a chance to sell part of their water that is proving to be less reliable, retire some debt or invest more strategically (Wheeler et al. 2012), which may benefit certain regional communities. However, while this will benefit certain farmers, especially those who are seeking to retire, the buy-back program may have implications for future farm viability, especially for irrigation farms that are too small to operate as dryland operations. Therefore, we suggest that further research is needed to understand the likely effects and costs for regional communities of water reforms.

In terms of benefits, there remains a need to understand critical thresholds across ecological assets across the Murray-Darling Basin, including conditions under which a collapse of ecosystems can be anticipated and how these thresholds can be avoided. Further research is required to evaluate the extent of these system risks and social preferences associated with different pathways.

Lastly we have suggested that effort go into evaluating a wider range of options. This will include alternatives involving smaller and larger allocations of water, as well as other alternatives such as managing entitlements for improving environmental quality in the Murray-Darling Basin. Further discussion is required on how much water is needed but also on the flow regimes that will enable best use of the reallocated water.

Acknowledgements
We would like to thank Jeff Connor and Rosalind Bark for providing useful comments on the draft paper and the very useful comments from two referees. Thanks to Martin Nolan for preparing the map of the Murray-Darling Basin.

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Appendix

Table 1: Proposed Value Estimates from Morrison and Hatton MacDonald (2010)

<table>
<thead>
<tr>
<th>Regions</th>
<th>Native vegetation $'000 (present values)</th>
<th>Native fish $'000 (present values)</th>
<th>Colonial Waterbird breeding $'000 (present values)</th>
<th>Waterbirds and other species $'000 (present values)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1% increase in healthy native vegetation</td>
<td>1% increase in native fish populations</td>
<td>1 year increase in frequency of breeding</td>
<td>Unit increase in number of waterbirds and other species present</td>
</tr>
<tr>
<td>Barwon-Darling</td>
<td>$3,594</td>
<td>$667</td>
<td>$24,693</td>
<td>$3,578</td>
</tr>
<tr>
<td>Border Rivers</td>
<td>$2,437</td>
<td>$414</td>
<td></td>
<td>$1,086</td>
</tr>
<tr>
<td>Campaspe</td>
<td>$3,363</td>
<td>$2,990</td>
<td></td>
<td>$2,299</td>
</tr>
<tr>
<td>Condamine-Balonne</td>
<td>$2,926</td>
<td>$414</td>
<td></td>
<td>$1,086</td>
</tr>
<tr>
<td>Mt-Lofty Ranges</td>
<td>$1,494</td>
<td>$1,329</td>
<td></td>
<td>$1,022</td>
</tr>
<tr>
<td>Goulburn-Broken</td>
<td>$5,019</td>
<td>$4,463</td>
<td></td>
<td>$3,431</td>
</tr>
<tr>
<td>Gwydir</td>
<td>$3,482</td>
<td>$667</td>
<td>$24,693</td>
<td>$1,749</td>
</tr>
<tr>
<td>Lachlan</td>
<td>$3,482</td>
<td>$667</td>
<td>$24,693</td>
<td>$1,749</td>
</tr>
<tr>
<td>Loddon-Avoca</td>
<td>$3,363</td>
<td>$2,990</td>
<td></td>
<td>$2,299</td>
</tr>
<tr>
<td>Macquarie-Castlereaghe</td>
<td>$3,482</td>
<td>$667</td>
<td>$58,802</td>
<td>$1,749</td>
</tr>
<tr>
<td>Moonie</td>
<td>$1,961</td>
<td>$277</td>
<td></td>
<td>$728</td>
</tr>
<tr>
<td>Murray</td>
<td>$79,098</td>
<td>$73,794</td>
<td>$375,369</td>
<td>$12,203</td>
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<tr>
<td>Murrumbidgee</td>
<td>$3,594</td>
<td>$667</td>
<td>$24,693</td>
<td>$3,578</td>
</tr>
<tr>
<td>Namoi</td>
<td>$3,482</td>
<td>$667</td>
<td></td>
<td>$1,749</td>
</tr>
<tr>
<td>Ovens</td>
<td>$3,363</td>
<td>$2,990</td>
<td></td>
<td>$2,299</td>
</tr>
<tr>
<td>Paroo</td>
<td>$2,598</td>
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<td>$15,337</td>
<td>$1,086</td>
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<tr>
<td>Snowy Mountains Scheme</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Warrego</td>
<td>$2,598</td>
<td>$414</td>
<td></td>
<td>$1,086</td>
</tr>
<tr>
<td>Wimmera</td>
<td>$2,660</td>
<td>$509</td>
<td></td>
<td>$1,336</td>
</tr>
</tbody>
</table>

Source: These estimates are based on original research undertaken by a number of researchers over the past 23 years. Morrison and Hatton MacDonald (2010) provide this inventory of results in their paper.
Table 2: Water Reliability in the southern Murray-Darling Basin

<table>
<thead>
<tr>
<th>Year</th>
<th>High reliability entitlements</th>
<th>Lower reliability entitlements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vic Goulburn</td>
<td>Vic Murray</td>
</tr>
<tr>
<td>1998-99</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>1999-00</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>2000-01</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>2001-02</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>2002-03</td>
<td>57%</td>
<td>100%</td>
</tr>
<tr>
<td>2003-04</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>2004-05</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>2005-06</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>2006-07</td>
<td>29%</td>
<td>95%</td>
</tr>
<tr>
<td>2007-08</td>
<td>57%</td>
<td>43%</td>
</tr>
<tr>
<td>2008-09</td>
<td>33%</td>
<td>35%</td>
</tr>
<tr>
<td>2009-10</td>
<td>71%</td>
<td>100%</td>
</tr>
<tr>
<td>2010-11</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Figure 1: Map of the Murray-Darling Basin with irrigation areas and Ramsar sites identified
Australia’s biosecurity: future challenges for animal industries

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Abstract. Australia’s very good animal health status faces a wide range of biosecurity challenges that will arise during the next decade from changes in disease risk, ecosystems, technology and the policy environment in which animal producers operate. An understanding of these challenges should help enable producers to adopt management strategies to make their enterprises more resilient, as well as help policy-makers make better-informed choices to maintain and improve the health of Australia’s animals and animal industries.

Keywords: animal health, biosecurity, climate change, ecosystem change, emerging diseases, environmental change, policy, risk, risk analysis, technology.

Introduction

Australia enjoys a very good animal health status and remains free of many major animal diseases such as foot-and-mouth disease (FMD), highly pathogenic avian influenza (‘bird flu’), classical swine fever, and rabies. This enviable status faces a wide range of biosecurity challenges during the next decade. These range from changes in disease risk, ecosystems, technology and the policy environment in which animal producers operate.

Australia’s animal health status

Australia’s animal health status can change if there are incursions of diseases that do not occur here (i.e., exotic diseases), re-emergence of diseases that are already in Australia (i.e., endemic diseases), or the emergence of previously unknown diseases (i.e., ‘new’ diseases) here.

Incursions of exotic diseases can occur naturally or with human assistance. New strains of bluetongue virus enter when tropical weather events dump infected insect vectors in northern Australia. Various strains of avian influenza are brought into Australia by migratory birds and some mutate and become virulent leading to disease outbreaks in poultry, as occurred here in five years (during the period from 1976 to 1997), and led to successful eradication responses on each occasion. Incursions also occur inadvertently through human assistance by people, goods, or vessels coming from areas where exotic diseases occur (e.g., the incursion of equine influenza here in August 2007, resulting in infection on more than 10,000 properties and a successful eradication response in which the last case was recorded in December 2007). Human assistance may also be deliberate, such as smuggling (e.g., of birds’ eggs, the most likely means of entry of pigeon paramyxovirus in 2011) or malicious activity such as from acts of bioterrorism (deliberately introducing a pathogen into a population to cause disruption). In addition to microbial disease agents such as viruses and bacteria, animal and human diseases can also result from incursions of pests and parasites, while some incursions of exotic pests cause mainly environmental damage (e.g., marine pests such as black-striped mussel, which entered Australia in 1998, but was eradicated).

Re-emergence of endemic disease can occur with changes in the distribution, virulence, prevalence or host range. This has occurred in Australia, for example, with Newcastle disease in poultry after a mild strain of the virus, first recognised here in 1966, slowly mutated over time and became highly virulent to poultry. The resulting outbreaks and control responses caused the death or destruction of more than 2 million birds between 1998 and 2000, and led to ongoing preventive vaccination of poultry here since then.

Another example of re-emergence of an endemic disease is anthrax, which was inadvertently introduced into Australia in 1847 and now occurs only occasionally, typically in small numbers of sheep or cattle on single properties in the ‘anthrax belt’ from the centre of New South Wales to northern Victoria and Gippsland. However, on rare occasions outbreaks may involve large numbers of animals (e.g., an outbreak on more than 80 properties in the Tatura district of Victoria in 1997) or occur outside the ‘anthrax belt’ (e.g., in the Hunter Valley in New South Wales in 2007).

‘New’ diseases, previously unrecognised or unknown to science, have been identified on several occasions in Australia during recent years. Some of these ‘new’ emerging diseases cross from wildlife into domestic animals and, sometimes, people (e.g., Hendra virus, involving bats, pigs and humans, first described in 1997; Menangle virus, involving bats and pigs, first described in 1994; and Bungowannah virus, the cause of porcine myocarditis, first described in 1996). Some of them also arise and, at least to date, stay in free-living (‘wild’) animals
(e.g., pilchard herpesvirus, first described in 1995; Tasmanian devil facial tumour disease, first described in 1996).

The cost and other adverse effects of diseases in Australia can be very high. For example, a single case of bovine spongiform encephalopathy (BSE or 'mad cow disease') would result in lost trade worth several billion dollars a year and the cost of an outbreak of FMD in Australia was estimated in 2001 to be about $13 billion (Productivity Commission 2002), without including social costs (e.g., suicide or long-term health impacts on producers), the negative effect on land values, and the effect on the viability of regional towns and communities. The outbreaks of virulent Newcastle disease in 2001 cost $50 million in direct losses such as compensation, but the total costs were far greater. The full economic effects of the incursion of equine influenza in 2007 have not been calculated but are substantial (Hoare 2011; Smyth et al. 2011).

Changing disease risks

Globally, animal diseases are having increasingly adverse effects on human health, animal production and trade, rural development and the natural environment. Factors contributing to the increase of disease include demographic changes, intensive animal production, globalisation and trade, urbanisation and other environmental changes — including climate change — that influence the ecology of disease agents (Cohen 2000). These effects will continue unless strong and well-coordinated measures are taken to prevent and manage major animal diseases at source.

Worldwide, production-diminishing infectious diseases, such as FMD and classical swine fever, resulted in severe hardship for many farmers, hinder livestock development, and restrict or close access to markets (Thiermann 2004). The highly infectious nature of such diseases has resulted in transboundary spread, particularly from countries that have suboptimal veterinary services and animal health systems, creating risks to countries (like Australia) that are free of such diseases.

Many emerging diseases are 'transboundary diseases' that often spread between countries and continents. In addition, up to 75% of newly recognised infectious diseases of humans are zoonotic, this is transmitted from animals (domestic animals and wildlife) to humans (Woolhouse 2002; Morse 2004; Slingenberg et al. 2004; Woolhouse and Gowtage-Sequeri 2005). Wildlife diseases can also have significant effects on the wildlife hosts themselves, in some cases threatening biodiversity (Daszak et al. 2000; Thomas et al. 2004), and the livestock–wildlife interface is a source of introduction of diseases to domestic animals and humans (Osofsky et al. 2005). Climate change is part of the larger set of environmental and ecosystem changes that are promoting the emergence and re-emergence of animal diseases. There is considerably more information on the likely effects of climate change on human health than there is on its likely effects on animal health and production (Baylis and Githenko 2006). To help rectify this situation, the World Organisation for Animal Health (OIE) reviewed the effect of climate change on the epidemiology and control of animal diseases (de la Rocque et al. 2008) and surveyed member countries to gain chief veterinary officers’ views on the effect of climate and other environmental changes on animal health. Responses to OIE’s questionnaire revealed that most countries’ chief veterinary officers are concerned by the effect of climate and other environmental change on emerging and re-emerging animal disease, and are not confident that veterinary institutions are effectively preparing professionals who are capable of understanding the effect of such changes on animal health and production (Black and Nunn 2009).

Emerging and re-emerging food safety issues such as contamination and zoonotic food-borne diseases pose problems throughout the world. Episodes of food-borne illness in recent years include BSE, Escherichia coli O:157, Campylobacter jejuni and salmonellosis. As well there are problems associated with antimicrobial resistance and a range of chemical residues and toxins (Schlundt et al. 2004; Dagg et al. 2006).

Forecasts suggest that the world’s population will increase from about seven billion people now to more than nine billion by 2050, with most of this growth occurring in Africa, Asia, and Central and South America. Some authorities estimate that demand for animals and animal products will increase between 2% and 3% per annum for at least the next 10 years, and argue that much of this demand can be met from developing countries if animal diseases there are better managed (FAO 2009). However, given the rapid rate of growth in human population there is increasing concern about global food security (FAO 2011).

Changing ecosystems

Animal production has significant effects on ecosystems worldwide, particularly through negative impacts on land, water, biodiversity and climate (Steinfeld et al. 2006), and development agencies are increasingly including livestock as a focus of attention.
(World Bank 2009). For example, responses to climate change will include alterations in livestock production systems, and some of these will have animal health implications. Climate change thus contributes to changing animal health risks both directly (e.g., via the effects of increasing temperature) and indirectly (e.g., via changes in production systems designed to mitigate or adapt to climate change).

Many animal diseases are affected by weather, which can affect the distribution of disease, the time when outbreaks occur, or the severity or intensity of outbreaks (Bayliss and Githenko 2006). Climate change is likely to increase the vulnerability of the primary industry sector to both biophysical and economic stresses. In particular, it is likely to have a significant effect on the supply of water as a result of increased temperatures, increased evaporation, and reduced rainfall in some areas of Australia. Increased climate variability and increased frequency and severity of extreme weather events such as drought are also likely to lead to additional stresses (Pittock 2003).

Within Australia, climate change will affect future patterns of livestock density, distribution, production and trade that could also affect the risk of disease. For example, there may be a shift in agriculture, including livestock production, from temperate areas of southern Australia to the northern tropics as a result of the expected effect of climate change on each of these regions. Some breeds (e.g., meat sheep for prime lamb production, European British breeds of dairy cattle) are likely to be disadvantaged by a more sub-tropical climate and by their greater susceptibility, in comparison with more tropical breeds, to a range of vector-borne diseases to which they will be more exposed.

Australia has complex and highly variable weather (Pearman 1995), even without any increased variability as a result of climate change, and such variability makes climate modelling difficult. However, as data going into models and the models themselves improve, there will be a reduction in associated uncertainties and an increase in the validity of model outputs and of consequent projections and inferences related to animal production and animal health. For example, a study of the projected effect of climate change on wheat, beef, sheep meat and wool (Heyhoe et al. 2007) examined likely impacts of a high-rainfall and a low-rainfall scenario by 2030 on the Western Australian wheat belt and the central western slopes and plains of New South Wales. Under the low-rainfall scenario, productivity was projected to fall by 1.8% to 4.2% in the New South Wales study area and by 0% to 7.3% in the Western Australian study area. With the adoption of a number of adaptive responses, the projected fall in productivity was halved.

If changes in climate allow the vectors of tick-borne diseases to expand periodically into new areas, severe outbreaks of diseases such as babesiosis and anaplasmosis can be expected in susceptible animals of all ages. Higher temperatures increase the rate of development of some pathogens or parasites that have part of their life cycle outside an animal host. This may shorten generation times and lead to increases in the population of some pathogens and parasites. For example, the range of the cattle tick (*Boophilus microplus*) is likely to extend southwards and lead to significant losses (from a decline in total live-weight gain and from tick-borne diseases) that, without new control measures, will reduce the productivity of the beef cattle industry (White et al. 2003).

In areas where climate change results in more humid conditions and higher summer rainfall, the prevalence of blowfly strike on sheep can be expected to increase, with consequent higher costs of prevention and treatment as well as reduced wool production and quality (Harle et al. 2007). The prevalence of some pests and parasites might also become more variable in response to increased variation between seasons (e.g., they may appear earlier in a season and go through more generations each year). In sheep, these effects might be exacerbated by the reduced nutrition resulting from increases in poorer quality forage species and decreases in the nutritional value of existing species as a result of climate change (Harle et al. 2007).

Climate change will not increase the risk from all diseases and many livestock diseases will be little affected, or even unaffected, by climate change. Such diseases include those that are transmitted primarily by close contact between hosts (e.g., mastitis) or that are food-borne (e.g., salmonellosis). In some cases, the risk from disease may decline. For example, the snail intermediate hosts of the liver fluke *Fasciola hepatica* depend on moisture to survive and multiply. The decreased rainfall and soil moisture (particularly in summer) that is projected as a result of climate change in areas of south-eastern Australia where fascioliasis occurs is likely to reduce the current prevalence and distribution of the disease.

As both livestock producers and wildlife adapt to climate change (e.g., via changes to where livestock are farmed and changes in the
distribution of wildlife populations in response to climate-induced changes to water and vegetation), opportunities will undoubtedly arise for further diseases of wildlife to infect domestic animals and humans. In areas where one of the adaptations to climate change is increased intensification of animal production, there will also be further opportunities for the emergence of previously unknown diseases and the re-emergence of known endemic diseases (Otte et al. 2007).

**Changing technology**

Science and technology are changing and are likely to continue to advance rapidly. Advances in areas such as molecular biology (e.g., genomics, proteonomics) offer new ways to diagnose diseases better — faster, on-site (‘penside’ or ‘point-of-care’), cheaper and more accurately. They also offer potential new ways to prevent (e.g., by vaccination), control and treat diseases.

Rapid advances in information technology have led to tools such as geographic information systems (GIS), remote sensing and disease modelling that can all be applied to improve disease prevention, preparedness and response. Recent advances in information and communications technology have caused an explosion of the information available on the internet and the widespread use of ‘new media’ (e.g., Facebook, Twitter). Monitoring such open-source information and using techniques such as emerging issues analysis and other strategic foresight tools to analyse enables semi-automated rapid detection of disease events worldwide and provides insight and intelligence to inform disease prevention and control and reduce the risk of incursions. Advances in disciplines such as epidemiology and disease ecology are enhancing our understanding of factors that drive the emergence or re-emergence of disease. Such advances will increasingly enable us to target surveillance to areas where such risk factors are highest and to develop and apply preventive actions to reduce risk factors that drive disease.

Enhanced disease surveillance systems are a key component of maintaining and improving biosecurity. Local and global surveillance systems can be improved in a number of ways, such as approaches that combine data from a range of different sources and scales, including sourcing data on some of the drivers for disease emergence. The development of new technology for disease diagnosis will also influence disease detection and control. For example, the availability of robust and reliable point-of-care tests will enable earlier detection of disease and earlier response to contain outbreaks. Such developments, combined with new technology in vaccines (Breeze 2006) that enable the differentiation of vaccinated from infected animals, will offer cheap and effective improvements in disease surveillance and control. However, such new technology will achieve little unless accompanied by a well-trained and well-prepared animal health systems and animal producers.

There is a clear need for veterinarians, medical specialists, and wildlife and environmental experts to adopt an interdisciplinary framework such as ecosystem health (‘ecohealth’) or ‘one health’ (Waltner-Toews 2004, Parkes et al. 2005, Whittington 2006, McMichael et al. 2007). One of the many challenges with the use of new technology is to ensure that it is used in an interdisciplinary environment where its application is enhanced by the insights provided through the subject knowledge of specialists in different disciplines working together. Embracing this approach can require a fundamental shift in thinking as specialists in the medical and veterinary scientific and technical disciplines traditionally involved in disease prevention and control work more with other specialists to address emerging disease risks. Other disciplines that need to be involved include social sciences (e.g., anthropology, communications), economics, environmental sciences (e.g., ecology), ethics, and policy and politics). Similarly, there is a need for changes in the education and training of animal producers to promote better stewardship of the land they manage and to encourage them to apply new technology in adaptive strategies that enhance biosecurity and minimise the negative effects of climate and other environmental change on animal production and health.

**Changing policy context**

The broad policy context around biosecurity is one of continuing growth of globalisation and trade, and with it the potential for what many call ‘pathogen pollution’ — the spread of pathogens and pests with that trade. Australia has long had a strong quarantine presence at the border, with close inspection of incoming passengers, goods and mail to help prevent the entry of disease agents. Greater emphasis is now being given to pre-border biosecurity such as capacity-building in animal disease control in neighbouring countries. These activities help both to control known disease risk in these countries, thus reducing the risk of spread to Australia, and also provide early warning and intelligence of changing risk such as from newly recognised emerging diseases. Greater emphasis is also being given to offshore audit and verification in countries that are major
trading partners. These activities help manage biosecurity risks offshore and aim to ensure that what is exported to Australia is safe.

**Changing expectations**

Society, particularly in developed countries, is increasingly demanding assurances about safety, including safety from infection from animal diseases. Twenty years ago when a disease outbreak occurred, animal health authorities faced questions such as 'What effect will it have on production or productivity?', 'Will it affect trade?', 'How much will it cost to control it or eradicate it?', and, occasionally, 'Could it infect people?'. Now, the very first question animal health authorities are asked is 'Can you guarantee it won't affect people?' That is a very different question, and a much harder one to answer, particularly when the outbreak is of a newly identified or previously unknown disease. Animal health authorities and animal producers will continue to be challenged to respond to this question as 'new' diseases emerge.

Within Australia, as in many other developed countries, intensification of animal production is likely to continue, not only in pigs and poultry but also increasingly in beef cattle feedlots, dairy production and aquaculture. However, intensive facilities, with large numbers and high densities of animals, increase the risk of disease emergence and need high standards of biosecurity to maintain the health of stock. In developed countries, public concern about intensive animal production focuses on issues related to animal welfare, effluent disposal, and the use of chemicals (e.g., hormones, probiotics, therapeutics). Such concerns are likely to continue to grow as more consumers’ expectations expand to include greater assurances about the origin and safety of food and the welfare of the animals that produce the food, fibre and other products they use. There will also be, particularly in developed countries, increased public demand to demonstrate more rigorously the safety of new technology (e.g., gene technology, cloning, nanotechnology) and its products. Society will continue to demand increased assurance about environmental effects of animal production, the welfare of farmed animals, and the safety of animal products and the technology used in animal production.

These changing expectations will lead to greater demands to reduce the destruction of large numbers of animals as a primary tool to contain and eradicate outbreaks of infectious animal diseases. Internationally, 'slaughter-out' responses are increasingly unacceptable to society, especially if other control options (for example, vaccination) are available. The influence of public opinion on outbreak responses is illustrated by the response to FMD in the United Kingdom in 2001–02 in which the public response to media coverage of the imminent destruction of a single photogenic white calf ('Phoenix') almost stopped the eradication program. Consideration of the ethics of the destruction of millions of poultry in response to ongoing outbreaks of avian influenza in many countries — particularly in developing countries, where animal protein is in scarce supply and poultry production is a significant source of income for millions of smallholder farmers, — is also likely to lead to changes to the way authorities manage animal disease outbreaks in the future.

**The changing science–policy interface**

The use of formal science-based risk analysis frameworks will become more important in identifying, characterising, assessing and managing risks, both real and perceived. Risk analysis is a demanding, complex and resource-intensive process. In the natural resource area generally (including quarantine and biosecurity), it involves consideration of scientific and economic factors, often requiring the use of multidisciplinary teams. In complex analyses of animal diseases, risk assessment teams may need to include specialists with skills in disciplines such as communications, mathematics, statistics, computer simulation and disease modelling, ecology and environmental science in addition to those in risk analysis, animal or plant health, and economics (Nunn 1997; 2001). Sound risk management approaches will need to be applied at all levels of the supply chain. Given that problems will occur in even the best-managed systems, more effective and more refined approaches to contingency planning will be necessary to protect animal production and health, safeguard human health, and support consumer confidence.

Perceptions of risk by stakeholders or the general public often align poorly with those of ‘experts’, and a rapidly growing body of work on risk perception and communication has defined a number of key factors that determine individual and group perceptions of risk. For example, factor analysis has shown that hazards that are perceived as unfamiliar or provoke dread are assigned a higher risk than can be demonstrated statistically (Slovic 2000). Unfamiliar or unknown hazards, even with a low probability, that are regarded as having potentially catastrophic effects are perceived as high risk and provoke strong public demands for government to regulate and
Science provides a framework for analysis and synthesis that can inform policy. However, science is still largely based on classical, reductionist approaches that may not always be appropriate in situations of high complexity and uncertainty. When both uncertainty and the consequences of a decision are high (as often occurs with emerging diseases), a more appropriate strategy may be that of 'issues-based post-normal science' (Funtowicz and Ravetz 1994). This strategy aims to engage an 'extended peer community' including all stakeholders to evaluate the quality of scientific information provided as input to the policy process. Proponents of 'trans-science' (e.g., Weinberg 1985) distinguish between science (or 'research science') and trans-science (or 'policy science') and argue that there are some questions that can be asked by science, but cannot be answered by science. Under this approach, increased complexity and uncertainty of questions should result in greater democratisation of how to 'do' science when scientific ways of knowing break down, especially if there is a high 'dread' factor (e.g., environmental risk), and that this compels scientists to look beyond the (known) facts to make judgments or determinations. Others (e.g., Carolan 2006) argue that increased complexity and uncertainty require a focus on 'expertise' rather than science, and recognise public expertise that allows the explicit incorporation of values and changes the focus from questions of 'what is' to questions of 'what should be done'.

**Conclusion**

Australia’s animal industries face a wide range of biosecurity challenges. These challenges arise from changes in disease risk, ecosystems, technology and the policy environment in which animal producers operate. Australia’s enviable animal health status will continue to be threatened by incursions of exotic diseases, re-emergence of endemic diseases, and the emergence of previously unknown diseases here. However, Australia has a strong legislative and governance basis for animal disease prevention, preparedness, response and recovery — including strong partnerships between animal health services and the animal industries they serve. This sound foundation, combined with a range of strategic approaches to identify and minimise biosecurity risks, should ensure that Australia is well-placed to maintain and improve its animal health status, despite the range of future biosecurity challenges it faces.

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Finding tomorrow’s agricultural workforce

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Abstract. The labour shortages which face the Australian agricultural sector could be described as having both acute and chronic aspects. Acute labour shortages can be related to short-term factors; examples include the impacts of extended drought and strong growth within the mining sector which has led to strong competition for labour and a decline in the available labour force. The potential emergence of chronic or long-lasting labour shortages related to a decline in new entrants seeking employment in the sector is a significant issue. While acute labour shortages have been a significant focus for the agricultural industries for many years, agricultural industries now need to invest in strategies to address chronic workforce shortages and emerging skills gaps. Raising awareness among young Australians about the career opportunities within the agricultural sector is seen as an increasingly important strategy. A significant challenge will be how to support these strategies over the long term.

Key Words: Agricultural labour, career opportunities, awareness.

Introduction
Understanding and addressing current and future demands for labour and skills is an ongoing area of interest for those engaged in the agricultural sector. Future employment demand within the Australian food and fibre sector, and the capacity of the sector to compete for employees, will be influenced by a range of factors, including: Government policy, consumer demands, environmental constraints, global competition and the interaction between agriculture and other sectors of the economy. These factors present challenges and opportunities for the sector, as well as uncertainty. This paper will focus on addressing the existing demands for skills and labour, including the substantial replacement demand that is emerging within the sector.

Examples of recent work to understand the demand for skills and labour includes the Australian Farm Institute report (AEC group 2010) examining the current and future human resource requirements of Australian agriculture and the Agrifood Skills Australia (ASA 2011) annual environmental scan of the factors shaping and impacting on the agrifood workforce and how the industry and training systems are responding. Government and industry workforce, skills and training initiatives were also reviewed by the Industries Development Committee Workforce, Skills and Training Working Group in 2009 for their appropriateness. Fundamental to a better understanding of this important issue is a better knowledge of the demand and supply of skills and labour within the sector.

Future demand for skills and labour in the sector is difficult to project and subject to a range of variables. This paper focuses on the replacement of the workforce associated with the Australian agricultural sector, against a backdrop of continued growth in global demand for food and fibre. Significant growth in global food demand is expected in coming years, with the Food and Agriculture Organization of the United Nations (FAO) estimating that global food production will need to increase 70 per cent by 2050 in order to meet this projected food demand (FAO 2009).

Australian agriculture makes a significant contribution to the Australian economy and the management of Australia’s natural resources, and also contributes to domestic and international food security. Farmers occupy and are responsible for the management of Australia’s landmass (DAFF 2010) and in 2009-10 Australian food exports were valued at $24.3 billion (DAFF 2011). Australian farmers produce almost 93 per cent of Australia’s daily domestic food supply and contribute to offsetting global food demand. Australian farmers produce one per cent of the world’s food, but are the source for almost three per cent of the food traded globally feeding 40 million people outside Australia (PMSEIC 2010).

Access to appropriate skills and labour is a critical factor in maintaining the productivity, sustainability and profitability of the agricultural sector. The agricultural industries have been involved in dealing with acute labour issues over a considerable time. While immediate labour and skills shortages are an acute issue and make the headlines, it is the issue of an emerging chronic shortage of new entrants and graduates to the sector which potentially presents the most significant challenges.

Current environment, the acute demands
There are many aspects to the current acute labour shortages faced by the Australian agricultural sector and which relate to both
shortages of both skilled and unskilled labour. Labour force statistics indicate a downturn in employment in 2003 which has continued until 2010 (see Figure 1). This downturn coincided with widespread drought in eastern Australia which reduced employment opportunities, and increased demand and competition for labour from the mining sector. Poor seasons over recent years have also had flow-on impacts for regional economies and communities, which also influences the attractiveness of regional Australia to potential employees.

The recent impact of drought on employment has come on top of long-term trends that have seen consolidation of farms in many agricultural industries and regions. Over the 15-year period to 2001, prior to the recent drought, the number of farming families declined by 31,800 (22 per cent). They may have left the industry for a variety of reasons, including personal (e.g., retirement), economic (e.g., industry restructuring) or environmental (e.g., drought) reasons. Other business related factors such as commodity prices may also play a role in decisions about timing to leave the industry, with lower commodity prices, and hence potentially lower property prices, tending to delay decisions to leave.

Farm employment labour statistics over the past 8 years (see Figure 1) indicate that approximately 80,000 to 100,000 individuals have left the agricultural labour force (ABS 2003). Because of the sustained downturn in employment, it is likely that a number of individuals have permanently left the industry since the early 2000s. It is also likely that farmers have developed efficiencies in their operations or improved farm practices and infrastructure which will have led to some decline in the overall labour requirement of the sector. However, with the widespread rains which occurred in 2010 and the recovery of many water storages there is expected to be an increase in demand for labour in the sector. Agrifood Skills Australia suggests that the recovery in the workforce as industry recovers from drought will be between 10,000 to 20,000 workers each year for the next five years (ASA 2010).

The Australian Council of Deans of Agriculture (2009) has examined the demand for skilled individuals with tertiary qualifications in rural and regional Australia. The ACDA published a study in 2010 examining the job market in agriculture in Australia (Pratley and Hay 2010). It reviewed 50,600 vacancies advertised in the metropolitan and regional print media as well as the internet for a 3-year period from 2007 to 2009. A consistent demand for 15,000 agricultural employees was identified over the study period, with a ratio of 3:2 for agricultural production related jobs to positions in agribusiness. The ACDA has also published reports and submissions on the gap in graduate numbers. It estimates there may be as much as a six-fold gap between demand and graduate numbers and that graduate numbers are in decline (ACDA 2009). Importantly, the ACDA studies have highlighted that the way jobs were advertised was different between regional and urban Australia, with a particularly emphasis on advertisements for agricultural employees in the regional print media. This has implications for the way job data related to agricultural employment is collected and analysed, and the strategies required to understand the employment outlook for the sector.

**Long-term outlook, a chronic concern**

The agricultural sector is a major contributor to the Australian economy and has important linkages with other sectors of the economy. In 2009, 318,000 people were directly employed on Australian farms (ABS 2009). However, accurate and comprehensive information on future employment prospects and requirements for people in the sector and in its supporting industries is difficult to identify beyond the requirements of replacing the existing workforce. As mentioned earlier in this paper, the workforce demand and the capacity of industry to compete for employees will be influenced by a range of external factors which are difficult to predict. There will be an increasing requirement for innovation within the agricultural industries globally to address the national and international challenges related to food production. The challenges for agriculture have been articulated by a number of observers. The United Nations issued a call-to-arms for agricultural production to increase 70 per cent by 2050 to meet world population needs in the face of challenges to global food security (FAO 2009). The world population is projected to reach over nine billion by 2050, 34 per cent higher than the current population. Some projections for the Australian population suggest that it may reach 36 million people by 2050. At the same time the Final Report of the Garnaut Review (2008) notes that more than two and half million new jobs will need to be filled over the next two decades in areas either directly or indirectly influenced by the climate change response. The Garnaut Review noted that in addition to jobs in the ‘headline’ areas of the construction and energy sectors, areas of potential employment change include “transport, agriculture and a range of services in industry subsectors that barely exist today”. It seems likely that a number of
these roles will relate to agriculture and the land management sector.

Limited data are available on the demographics of industries and professions within the agricultural sector, but the data available provide a glimpse of the emerging challenges and potential chronic employment issues that the sector is facing. The Labour Supply and Skills Branch in the Research, Analysis and Evaluation Group of Department of Education, Employment and Workplace Relations (DEEWR) has compiled ABS Labour Force Survey statistics for a limited selection of professions within the agricultural sector, which have been published on the Job Outlook website.

Figure 2 shows the age profile of crop; livestock; and mixed crop and livestock farmers published by DEEWR and taken from the 2010 ABS Labour Force Survey. In 2010 the total number of crop, livestock and mixed crop and livestock farmers was 47,700, 105,100 and 42,200 respectively. The demographic data in Figure 2 indicates that there are large numbers of farmers over the age of 65 compared with the average age of the Australian workforce, in some cases more than nine per cent higher than the average, as well as relatively high numbers of farmers in the 45-54 and 55-64 age classes compared with the average workforce. The numbers of farmers in age classes 35-44 and younger are much lower than the Australian average.

The 2009 ABS Agricultural Commodities surveys indicate that there is a total of 135,996 farms in Australia, which includes enterprises for whom farming is not their primary business. Of the total number of enterprises, 120,941 farms are solely dedicated to agricultural production. The 2002 Australian Bureau of Agricultural and Resource Economics Farm Surveys Report indicates that 99 per cent of broadacre and dairy farms were operated by owner-managers in 2001 (ABARE 2008). Broadacre and dairy farms account for 68 per cent of commercial-scale Australian farm businesses (ABS 2009), and these farms are also responsible for the management of more than 90 per cent of the total area of agricultural land in Australia. They account for the majority of Australia’s family owned and operated farms. The future of how these farms are owned and managed will have a significant bearing on the future skills and labour required by the Australian agricultural workforce.

The age profile of farm workers in crop, livestock and mixed crop and livestock farms taken from the 2010 ABS Labour Force Survey is shown in Figure 3. The total number of farm workers across crop, livestock and mixed crop and livestock farms in 2010 were 28,000, 30,200 and 3,400 respectively. The data shown in Figure 3 indicate that a relatively high number of farm workers are from young age classes, particularly the 15-19 and 20-24 age classes, compared to the Australian average. This may reflect the relatively unskilled nature of the work as well as younger family members being employed on family farms, but also the need for temporary labour to meet needs around peak periods such as harvest and seeding.

The data shown in Figures 2 and 3 relate specifically to broadacre agricultural industries. There is a range of other industries including the horticultural, dairy and intensive livestock industries which are not included in these figures. It is likely that there are differences between the age profiles and nature of the workforce in these different industries and the industries will have their own specific challenges. For example, the seasonal nature of work in the horticultural industries creates acute seasonal labour demands which are quite different to those experienced in other industries. The NFF has been working with Government to establish long-term solutions to access labour, including the potential from overseas labour to meet peak labour demands. Sustainable solutions are required to address these labour demands, which may involve better engagement with regional communities and better recognition of the skills and experience which may already exist in these communities.

Access to professional services will present a chronic problem for the agricultural industries in the future. They draw on the skills of a range of science-based professions, veterinarians, chemists, environmental scientists, life scientists and others. The Employment Outlook for Science Professionals and Veterinarians produced by DEEWR (2010) (using the ABS Labour Force Survey) indicates that in the decade to 2010 the number of Science Professionals and Veterinarians12 in Australia rose by 25,800 (36.5 per cent) to 96,300. Agricultural and Forestry Scientists represent 7.5 per cent (7,300) of individuals within this group of professions, which is dominated by medical and environmental scientists.

12 The Science Professionals and Veterinarians cluster includes Agricultural and Forestry Scientists; Chemists and Food and Wine Scientists; Environmental Scientists; Geologists and Geophysicists; Life Scientists; Medical Laboratory Scientists; Veterinarians; and Other Natural and Physical Science Professionals.

The Employment Outlook for Science Professionals indicates that Agricultural and Veterinary Scientists have the largest share of mature age workers (48.5 per cent of the workforce over the age of 45) within the occupations grouped within the science cluster. Projections by Agrifood Skills Australia in its 2011 Environmental Scan (ASA 2011) suggest that by 2018 half of Australia’s agricultural scientists will be nearing retirement.

Within the agricultural science workforce there are specialists in a range of disciplines, for example soil science, plant breeding, taxonomy, entomology and pathology. It is probable that the number of individuals in some disciplines will have grown as the field develops (e.g., areas related to biotechnology) and numbers in others disciplines are likely to have decreased where the research area is considered more mature. For example, the loss of Australia’s skills and capacity in soil science and the need to rebuild this capacity in light of the challenges, such as the management of soil carbon, was discussed by Campbell (2008). Some of the Australian agricultural industries have become dependent on the research efforts or technical skills and experience of one or two key individuals, and the loss of these individuals would have a major impact on these industries. For example, the Rice Research and Development Plan developed by Rural Industries Research and Development Corporation (2008) recognised the ageing and depletion of the rice industry’s human resource research base and the need to address this as one of the research directions for the industry. The shift in the skills mix within the agricultural science workforce has also created challenges in workforce planning and succession, as new skills and the adoption of information technology is likely to have changed demands and requirements for particular professional skills.

The Department of Education, Employment and Workforce Relations (DEEWR) projects that demand for agricultural and forestry scientists will grow. The projected employment growth for the Agricultural and Forestry Scientists is expected to be 2.7 per cent (1,100) per annum over the next five years (to 2014-15). The issue of graduate numbers and succession in industry and the agribusiness sector have been raised by the National Farmers Federation (NFF) and others in recent times. The Rural Research and Development Council noted this in their National Strategic Rural Research and Development Investment Plan and reported that "With an ageing research workforce and evidence of an increasing skills deficit, there may already be insufficient capacity in the rural sector to develop and adopt innovations at the desired rate" (Rural Research and Development Council 2011).

The announcement from the Government in June 2011 that it will not alter the funding arrangements for the Rural Research and Development Corporations was welcomed by industry, and is a signal that there will continue to be a demand for skilled researchers in agriculturally relevant areas in Australia. A challenge for the Government and agricultural industries is how to further grow the public and private investment in agricultural research, development and extension, to drive innovation and increase employment in the area.

The global nature of the agricultural research workforce must also be considered. At an informal workshop held in Canberra during mid-2011, an executive from an international research-based agribusiness company indicated that the company was likely to experience a forty to fifty per cent turnover in their 4,000 to 5,000 strong agricultural research workforce over the coming years as a result of retirements. This type of example serves to highlight the global nature of the workforce, and the need to ensure Australia remains competitive in attracting and maintaining its research workforce.

**Strategies to address labour and skills shortages**

The Australian agricultural industries have been responding to the acute labour and skills shortages, as well as developing strategies to deal with chronic shortages and the long-term skills and labour needs of the sector. A range of strategies is required to attract and retain the labour and skills required by the sector, as well as encouraging new entrants into the industry and to the services which support the industry.

The NFF Labour Shortage Action Plan (NFF 2008) was developed in consultation with regional and sectoral industry bodies as well as government, with a focus on how to support the recovery of the agricultural workforce following the recent drought. Key strategies highlighted to address the gaps in labour and skills that were developed include:

- understanding workforce requirements to better target recruitment;
- publicise and promote the knowledge and technical intensive roles that are emerging in the sector, particularly in schools, to encourage new entrants and graduates;
- develop specific strategies to overcome issues of remoteness and seasonality in different industries to ensure regional
The need to improve the supply of labour, appropriately skilled to meet the engaged with these programs. To ensure that employers were successfully employment programs. Effort was required and confusion among employers related to the ARAMS Project was to address ‘fatigue regional industries. The third area identified which could reflect skills required by different the sectors, but also for flexible training units agriculture to allow labour to move between elements common to both mining and mining also faced a general labour shortage. For agriculture this means that two different sets of strategies are required to (a) attract and retain high quality skilled labour and (b) ensure that there is also a ready supply of ‘job-ready’ labour available, as skilled and general labour involve different people with a range of motivations and circumstances.

The ARAMS project identified three key areas to be addressed in order to improve employment outcomes. The first relates to the need for improved regional infrastructure and services, which are critical factors in encouraging skilled individuals to locate to regional centres. The second relates to the need for appropriate training programs to address labour shortages, with training elements common to both mining and agriculture to allow labour to move between the sectors, but also for flexible training units which could reflect skills required by different regional industries. The third area identified by the ARAMS Project was to address ‘fatigue and confusion’ among employers related to the provision, availability and accessibility of government education, training and employment programs. Effort was required to ensure that employers were successfully engaged with these programs.

The need to improve the supply of labour, appropriately skilled to meet the requirements of the agricultural industries, was discussed as part of the 2010 Australian Farm Institute (AEC group 2010) report on current and future human resource needs of Australian agriculture. The report identified the need for more accurate and timely information on labour and skills supply and demand, including recognising changes in seasonal demands for labour. This finding was shared by the 2009 Industries Development Committee Report to the Primary Industries Ministerial Council (PIMC) on workforce, training and skills issues in agriculture. Key findings of the AFI report included:

- the existing standards for classifying occupations (ANZSCO) and industries (ANZSIC) need to be expanded to improve the labour and skills information available for the agricultural and horticultural sectors;
- the data collected on agricultural production, employment and occupational statistics by various reporting organisations need greater consistency and concordance;
- regular and accurate measures of labour and skills shortages in the agricultural sector are required to understand current and future needs, including information on peaks and troughs in the seasonal production cycle; and
- vocational education and training (VET) packages need to be promoted and have the flexibility to deliver the particular skill sets required by sectors to meet seasonal production demands or the needs of individual agriculture/horticulture businesses, industries or regions.

Industrial relations and workforce planning to address acute labour shortages has been a strong interest for the NFF for a number of years. The NFF Labour Shortage Action Plan (NFF 2008) and ARAMS (NFF 2009) clearly identified the need to focus on training (particularly vocational training) to address labour shortages and the need to support regional development as a mechanism to encourage relocation and retention of the workforce. A number of strategies to better address acute labour shortages have emerged from previous work in this area including improved workforce information to understand demand, targeted training, better human resource management and support for regional development.

The NFF has continued to work in the area of vocational training and it is a key area of focus for Rural Skills Australia (RSA) and Agrifood Skills Australia. RSA works in conjunction with the NFF and its member bodies to improve the skills and capacities of...
new entrants, existing workers and primary producers alike through Australian Apprenticeships in general agriculture and horticulture, but also across a range of other agricultural areas. Agrifood Skills Australia is responsible for providing advice on workforce development, skills and labour needs in the industry, as well as advice to enterprises on training and workforce needs, advice to government on vocational education policy and the development of appropriate training packages for industry.

The 2009 Report to the Primary Industries Ministerial Council (PIMC) on workforce, training and skills issues in agriculture highlighted the opportunity to improve workforce planning and human resource management skills in the industry in order to attract and retain staff (Industries Development Committee Workforce, Skills and Training Working Group 2009). The opportunity to improve human resource management in the sector has the advantage that it can assist in addressing both acute and chronic labour and skills. Other benefits from improved human resource management in the sector identified include the potential to improve business performance and response to challenges such as changing market and service demands, and managing an ageing farm workforce. The ‘fatigue and confusion’ among employers identified by the 2009 ARAMS report suggests that to reap the benefits from improved planning and human resource management skills would require targeted investment in effort to support industry to bring about change.

The NFF has had an ongoing interest in regional development and addressing the higher cost of doing business in regional Australia. The NFF’s work in this area has focused on aspects including the need to maintain services, such as health care and telecommunications in regional Australia, as well as examining options related to fuel costs and regional tax thresholds which would have broader benefits for business. The development of new technologies associated with the roll-out of broadband in regional Australia may also provide an opportunity to diversify regional economies, provide better access to professional support to those working in regions and improved economic stability to regions, as well as securing ongoing access to services.

Community factors have also been identified as playing a role in attracting and retaining skilled workers in regional Australia. Kilpatrick et al. (2010) identified the important role that communities play in assisting mobile skilled labour to be integrated and retained, and the need for leadership within communities to support this outcome. The study found that mobile skilled workers were drawn to, wanted to be part of and stay in communities that were innovative, embraced diversity, accepted newcomers, and there was an environment of community confidence and sustainability. The report highlights that communities that were looking to attract, involve and retain skilled newcomers needed to be proactive in developing and managing their resources. This presents an opportunity both to attract and retain skilled labour in regional Australia.

Work has been undertaken within industries to look at mechanisms to facilitate new entrants to farming as well as succession within family farm businesses. The recent guide to succession, developed in collaboration by a number of Rural Research and Development Corporations, "Sustaining Families and Farms" is one example of the different types of support available to facilitate discussion about succession within farm businesses (Wilkinson and Sykes 2007). Anecdotally, reports from within industry indicate that the high value of the assets presents a barrier for new farmers looking to enter the industry, along with access to finance and appropriate support for early career farmers. Some programs have been established to assist new farmers in the industry. Examples of schemes include, the Victorian First Farm Grant Program which provides business planning and development support; the Young Farmers Finance Scheme operated by Rural Finance in Victoria which can assist in stock and equipment purchases, farm leases and land purchases; and the Queensland Government First Start Loan which can assist in farm purchases, leasing and farm establishment. Effective policy and programs to support farm succession and encourage new entrants to farming is an area which continues to be developed and will require further work.

The experience of AgriFood Skills Australia in capturing industry views and evidence for its Annual Environmental Scans is that the problems are complex and need new thinking from industry and government if they are to be addressed (Blewitt, pers. comm. August 2011). Key trends pertaining to the rural workforce include:

- demand for higher skills in labour and skills to address the business challenges and the need for innovation;
- greater reliance on contractors and professional advisors; and
- continued demand for casuals for seasonal work.

Some of the new thinking which will be required by industry to address these challenges include:
• the need for employers to design and name jobs that are attractive and challenging to new employees;
• the need to develop packaged conditions that may include incentives and non-cash benefits in order to compete with other employers, including the mining industry; and
• the need to overcome industry image and perceptions to change stereotypes and better explain the contemporary job, career and lifestyle opportunities within the industry.

Attracting young people to careers in agriculture

The challenge of chronic labour and skills shortages within the agricultural sector will require long-term solutions. A key focus will need to be attracting new entrants to the sector and raising awareness of it within the broader Australian community.

At a fundamental level, concerns have been raised at the level of awareness in the community and among children regarding agriculture and regional Australia. Surveys of school students by the Kondinin Group provide a snapshot of views held by children, and suggest that there has been a widening gap in their knowledge of the industry. A survey undertaken by Kondinin Group in 2002 indicated that only 20 per cent of school children surveyed had visited a farm, down on 88 per cent on a previous survey undertaken by the Group in 1997. The survey also suggested that there was a lack of understanding about farm operations and the technological intensity of farming. Strong stereotypes of farmers were reported to exist among the children surveyed. The Australian Council of Educational Research is currently undertaking a national survey of students and teachers to better understand the levels of awareness of agriculture which exist. The results of this work, which has been supported by the Primary Industries Education Foundation (PIEF), are expected to be available in late 2011.

The NFF sees initiatives focused on improving awareness of the agricultural sector as being extremely important both in addressing the emerging capability gaps and attracting employees to the sector, but also ensuring that the broader community is better positioned to understand and engage in public debate related to agriculture. A number of initiatives have been developed with a view to both increasing awareness and interest in agriculture among young people, teachers and parents and attracting individuals to take part in agriculture-related studies, or consider careers in agriculture.

Over an extended period of time, the NFF has observed the development of a number of programs that aim to attract and develop the agricultural workforce. However, many stakeholders have focused on addressing the issue on a sector-by-sector basis or on a single program basis with little interaction with other groups or existing programs. What is becoming apparent is that a ‘whole of landscape’ approach is needed to make an impact and to seek opportunities for greater efficiencies and collaboration on work in this area.

Figure 4 is a schematic diagram which illustrates a range of initiatives in place and how they engage with primary, secondary, and tertiary (undergraduate and postgraduate) education, as well as workforce (vocational) training and engagement with the broader community. The schemes listed in Figure 4 are extensive, but not exhaustive and a range of other programs exist outside those listed. Three cross-sector programs that are aimed at these early years of education are described below, they include PIEF, the Primary Industries Centre for Science Education (PICSE) and the Investing in Youth Program. Each has a particular focus that differentiates it, and together they provide a consistent suite of support for agricultural education and improved awareness of the agricultural sector from primary through to secondary and tertiary education.

Evidence to support the need to engage early in the education system to shape future education and career choices is increasing. The Australian Council for Educational Research (ACER) released survey findings that indicate that 40 per cent of first year students first considered university study while in primary school (ACER 2010). This sort of study illustrates that decisions about future directions and studies are made relatively early in life and that there is value of engaging in education early in school curriculums, before students have formed clear views on their career path. The experience of NFF, in engaging with schools-based programs, has highlighted that it is vital to engage with professionals in the primary and secondary school system to ensure programs are relevant to the curriculum and that they meet teacher and student demands.

The PIEF is responsible for aggregating existing educational resources and developing relevant materials for school years from Kindergarten to Year 12 which are aimed across the entire school curriculum. The primary industries will be used as a context for the development of learning materials across a range of subjects. The
PIEF has been established in recognition of the interest that many teachers (primary and secondary) have in teaching their students about food and fibre production, and to address the need for credible, authoritative and user-ready resources to be used in teaching. Ultimately PIEF can assist in developing community awareness and understanding about food and fibre production, but also encourage people to work in sectors related to the primary industries. The PIEF has been established as the peak body for primary industries education in Australian schools through collaboration between the agricultural industries, education and government sectors. For PIEF to develop a suite of diverse curriculum materials is a long-term exercise that may take up to 10 years at a cost in the order of $15 million. It will be important to ensure that there is a long-term commitment and that these materials can be updated and expanded over time.

The Primary Industries Centre for Science Education (PICSE) is a national program to attract students into tertiary science and to increase the number of skilled professionals in agribusiness and research institutions. The focus of the program has been the development of science curriculum materials for Years 10 through to 12 and support for teachers and students with agriculture-relevant science studies. The program has grown from pilot projects which began in 1998 and has the support of universities, government, industries as well as agribusiness companies. The PICSE program complements the work of PIEF, as it has a particular focus on the science curriculum in secondary school. It focuses on several key issues including developing student interest in specific careers that meet their personal interests and aspirations, and taking action to enrol in specific tertiary courses that lead to those career options. A strength of the PICSE program is the level of engagement it has with agribusiness companies that participate in work experience placements.

Some support exists for undergraduates moving from secondary school to university education, through the PICSE program and the support network of students who have been through that program, but also through the Investing in Youth program coordinated by RIRDC. It began with a pilot in 2010 and is now in its second year of operation. Undergraduate students are provided with financial support matched with a career mentor and assisted with relevant industry placements while they undertake their degree. At present the number of scholarships offered under this program is limited to approximately ten places each year, but there may be opportunities to grow these numbers and better integrate the studentships with the PICSE program in the future.

The aims and activities of the programs described are complementary – and investment is needed across the scope of their activities to make a significant impact in addressing future labour and skills needs, and collaborative and linked approaches are needed to ensure that gains made through one program can add value to others.

While these programs are designed to bring primary industries into the formal education system they also provide significant opportunities to raise the profile of agriculture in the broader community. However, these programs are all exposed to funding risks. Funding programs linked with Government and especially through the Rural Research and Development Corporations generally have durations of up to three years, which puts the programs at risk of termination before their value can be realised. For example, the 'Primary Connections’ and 'Science By Doing’ programs run by the Australian Academy of Sciences were subject to budget cuts in the 2011-12 Federal budget. These began in 2003 and were established to support professional development for science teachers to effectively engage primary and secondary school students on science curriculum. The cuts came despite positive evaluations of the program. For example, within five years of its introduction the Primary Connections resource was being taught in 76 per cent of Australia’s primary schools. While programs such as PIEF, PICSE and Investing in Youth obtain significant portions of their funding through short-term arrangements there is a significant risk that these programs will remain at the mercy of short-term funding decisions.

International experiences with skills and labour shortages

The challenge associated with identifying and recruiting an agricultural workforce is not restricted to Australia. Many of the issues and strategies associated with addressing acute and chronic workforce issues are shared with other countries. The size of agricultural industries and their workforces vary between countries, and the ability of the industry to compete for employees is also influenced by the economic and policy conditions within the country.

The Strategy for New Zealand Dairy Farming produced by DairyNZ, Dairy Companies Association of New Zealand and New Zealand Federated Farmers (2009) identifies “Talented and skilled people are attracted to,
and retained by, the industry” as a key outcome. The New Zealand dairy industry has seen a positive trend in the growth of the industry and significant changes in ownership structures. As a consequence demands have increased for labour on-farm and in supporting industries. Employees in the dairy industry also need increased skill levels to deal with the increased complexity, diversity and volatility of the industry. In order to achieve this outcome the industry has sought to:

- attract talented people (including: the promotion of careers to school leavers, tertiary students and early career change individuals; improve communication about opportunities in the industry; and influence government on legislation relating to immigrant workers);
- develop a quality work environment (including: improve the skills of industry as employers and human resource managers; and focus on innovation and improved productivity in the industry); and
- develop dairy people’s careers (including: improved training to meet skill requirements; developing leadership in industry; and the development of mentoring and coaching programmes to support people developing careers in the industry).

The Canadian Agriculture Human Resource Council has examined the human resource issues of the Canadian agricultural industries and worked to develop solutions to these challenges. Their work has included understanding the skills and development needs of the industry (CAHRC 2011) as well as a broader analysis of the trends likely to influence the skills of the agricultural industries in Canada (CAHRC 2010). Their work indicates that, as in Australia, the average age of farmers in Canada is increasing, and there has been a consolidation of farm enterprises (CAHRC 2010). Key areas identified by industry (CAHRC 2011) where work is required to improve human resource outcomes for the industry included:

- the need to engage with youth to promote and advocate career opportunities within the industry;
- the need for training that is relevant to the increasing sophistication of industry as well as meeting the needs of students and the development of leadership skills;
- improved apprenticeship programs to deliver training and support young people entering the industry;
- the need for industry to be better at self promoting and improving the profile of the industry within Canada;
- increased immigration to improve the labour pool; and
- improved communication between agricultural industries and other sectors on experiences and best practices to attract and retain staff within the sector.

The experiences from New Zealand and Canada indicate that trends influencing employment in Australian agriculture are shared in other countries. These trends include consolidation within the agricultural industries, volatility in the sector, but also the reducing visibility of the sector as an employer. The challenges of attracting employees to agricultural careers, the need to improve human resource management within the industry and develop appropriate skills in the workforce are also shared by agricultural industries, and there are opportunities for Australia to learn from these international experiences.

**Conclusions**

The skills and labour shortages which face the Australian agricultural sector have acute and chronic elements. In recent years acute labour shortages have been influenced by the impacts of extended drought, strong growth within the mining sector, but also seasonal aspects related to agricultural production systems. The emergence of a chronic shortage of skills and labour is a significant concern for the industry and strategies to address these shortages need long-term support.

To better understand both acute and chronic labour demand and supply issues, it is important that better data are collected on the scope of skills and the labour required, including both demand and supply elements. This information would help to understand the complexities of industries' requirements, which range from changes in the seasonal workforce requirements, to chronic issues associated with skills and labour supply. The challenges associated with workforce planning span a large number of the roles that exist in the agricultural sector.

The skills of employers in the agricultural industries must also be improved to ensure that industry has the workforce planning and human resource management skills to identify, attract and retain staff. Regional and community approaches must also be considered when attracting skills and labour to rural Australia to both promote the opportunities and assist in the retention of the regional workforce.

Limited surveys and anecdotal evidence indicate that there has been a decline in the visibility of the agricultural industries, particularly among urban Australia. A challenge for industry is to improve the
profile of the sector and awareness of the opportunities that it provides. Engaging in the education system through school-based programs provides a mechanism to encourage young Australians to consider a career in agriculture, and also to improve the awareness and understanding in the broader Australian community of agricultural and rural issues. It is important that there is a long-term commitment to school-based programs to ensure they bear fruit.

The skills and labour issues faced by the agricultural industries in Australia may have particular characteristics which are unique to Australia, but many of the issues are being experienced in other countries and there are opportunities to learn and benefit from international experiences in this area.

Acknowledgements

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Appendix

Figure 1. Australian farm employment

![Australian Farm Employment Graph](source)


Source: ABS, Year Book Australia, 2004-05, 2009-10, Catalogue No 1301.0.
Figure 2. The age profile of crop; livestock; and mixed crop & livestock farmers and the Australian average age profile taken from the 2010 ABS Labour Force Survey

**Age Profile (per cent share)**

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Crop Farmers</th>
<th>Livestock Farmers</th>
<th>Mixed Crop and Livestock Farmers</th>
<th>All Occupations</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-19</td>
<td>0.5</td>
<td>0.3</td>
<td>6.2</td>
<td>13.3</td>
</tr>
<tr>
<td>20-24</td>
<td>0.3</td>
<td>1</td>
<td>1.4</td>
<td>12.6</td>
</tr>
<tr>
<td>25-34</td>
<td>10.7</td>
<td>10.6</td>
<td>8.3</td>
<td>21.9</td>
</tr>
<tr>
<td>35-44</td>
<td>22.2</td>
<td>21.7</td>
<td>22.4</td>
<td>34.3</td>
</tr>
<tr>
<td>45-54</td>
<td>25.7</td>
<td>23.6</td>
<td>21.9</td>
<td>50.2</td>
</tr>
<tr>
<td>55-64</td>
<td>12.7</td>
<td>11.6</td>
<td>8.3</td>
<td>22.6</td>
</tr>
<tr>
<td>65 +</td>
<td>12.7</td>
<td>12.6</td>
<td>5.4</td>
<td>20.7</td>
</tr>
</tbody>
</table>

Source: ABS, Labour Force Survey, annual average 2010

Figure 3. The 2010 age profile of crop farm workers, livestock farm workers and mixed crop & livestock farm workers and the Australian average age profile taken from the ABS Labour Force Survey

**Age Profile (per cent share)**

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Crop Farm Workers</th>
<th>Mixed Crop and Livestock Workers</th>
<th>Live Stock Farm Workers</th>
<th>All Occupations</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-19</td>
<td>17.1</td>
<td>17.9</td>
<td>15.6</td>
<td>24.4</td>
</tr>
<tr>
<td>20-24</td>
<td>12.5</td>
<td>10.7</td>
<td>12.5</td>
<td>25.7</td>
</tr>
<tr>
<td>25-34</td>
<td>22.8</td>
<td>22.2</td>
<td>19.5</td>
<td>34.5</td>
</tr>
<tr>
<td>35-44</td>
<td>22.2</td>
<td>19.9</td>
<td>17.9</td>
<td>39.0</td>
</tr>
<tr>
<td>45-54</td>
<td>22.4</td>
<td>17.9</td>
<td>16.9</td>
<td>47.2</td>
</tr>
<tr>
<td>55-64</td>
<td>23</td>
<td>16.6</td>
<td>6.3</td>
<td>36.1</td>
</tr>
<tr>
<td>65 +</td>
<td>9</td>
<td>9.4</td>
<td>5.4</td>
<td>14.8</td>
</tr>
</tbody>
</table>

Figure 4. Graphic illustration of programs supporting the attraction and development of skilled labour in the agricultural industries

1. PIF
2. PICSE, PIF, Skills One, CAA, Allife, RSA, Industry specific e.g. Dairy Youth Australia
3. PICSE, Investing in Youth undergraduate scholarships
4. Post-graduate scholarships
5. Business skills, Technical skills development, Agrifood skills Australia, Nuffield, bursaries, tours
6. Industry leadership programs, ARLP, Trail Blazers, Mentoring
7. PIF, Community and consumer information, industry promotion
8. PIF, curriculum resource development
9. Curriculum resource development, research publications
10. Research publications, fact sheets, extension activities, conferences, websites
Planning farm succession: how to be successful
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Abstract. Planning farm succession is really good farm planning in its broadest aspect. Unfortunately very few farmers and their families have devoted sufficient time to working out how the farm business will be transferred. After demonstrating the importance of the farm succession issue, this article goes on to explaining a method of successfully tackling the process.

Keywords: succession, transfer, next generation, continuity, business plan.

Introduction
In a business sense, succession planning refers to the orderly transfer of management, responsibility, ownership and control, over time. In a farm business this could mean transferring the ownership of some of the machinery and/or livestock, transferring the management of part of the farm and eventually transferring ownership of the land.

Succession in the business and progression of the individuals’ careers are intertwined. Too often when the existing generation decides to move on, nobody is ready and waiting to follow. The next generation has left because of a variety of factors including being chased away or simply a sense of frustration. Alternatively, the next generation is ready to take over before the older generation is ready, or the next generation wants more time before returning to the family business.

Many people leave the family farm because of inappropriate employment relationships, unclear areas of responsibility and a reward package which is well below the industry standard for a non-family employee.

In order to provide sensible advice and guidance it is necessary for the farm management consultant to understand first, why this farmer is farming; second, why he or she is farming this farm; and third, why they are farming this farm in this way. In other words, it is necessary to establish whether or not there are historic constraints which restrict the choices of the farming family in the way they think about the farm as an asset, and whether they see it as a business where they are in control or a business which controls them.

Any succession plan has more chance of working if the people involved start to think about it earlier rather than later. For instance, building some off-farm assets is useful from a risk management point of view and can also make succession planning easier. Farm succession has become an important issue that the Australian farming community needs to deal with diligently and urgently to reduce future shock. This paper attempts to identify some key issues concerning farm succession and share opinions, formed through many years of practice and observation, about successful farm succession.

The farm succession issue is not new but the significance is increasing
Traditionally farm succession was not a big issue (for the purpose of this paper, the words “farm” and “station”, including pastoral leases, are interchangeable). If the eldest son wanted to farm he was given the farm and younger children got what was left over. In cases where the eldest son wanted to pursue another career, a younger son was given the farm. Many farms were big enough to be cut in half and in some cases they were mortgaged to allow the purchase of another farm.

The significance of the issue is increasing because as land prices have increased, the cost-price squeeze has impacted on profitability and a series of dry seasons have combined to make farming unattractive as a career. The result is that in many cases there is no obvious successor. Farm children have been encouraged to pursue other careers. The issue is causing concern in all parts of rural Australia, but the problem is more acute in areas where there is a long distance to travel to major centres. It is possible that many men who choose to work in remote areas will not be able to attract a life partner to join them. The issue is not confined to any socio-economic group.

How to successfully plan farm succession
To handle farm succession successfully, there are a number of principles to observe. There are also some steps that can be followed and models that can be made use of. In addition, in view of the changing business environment in which farms are operating, new thinking is also encouraged to provide new solutions. These important issues are discussed in this section.

Fundamentals to successful farm succession
When dealing with any farm succession matters, the following important principles need to be observed by those who are involved in succession plan:
• To work out what the existing generation wants to do – where they will live and what they will do in retirement (if succession is an option).
• To identify the needs, aspirations and expectations of each family member in each generation. Sometimes expectations need to be managed.
• To build, maintain and if necessary repair relationships between family members.
• To manage expectations amongst family members.
• To look at transferring management and control of the farm over time.
• To sort out how to transfer ownership of the farm (if that is what you want to do).
• To decide what deal there should be for the incoming generation and what provision to make for the non-farming children.

Traditionally, succession planning advice has been the province of accountants, lawyers or financial planners. But other advisors who can assist with ‘people’ and farming issues may also need to be part of the planning process using a team approach. The team of advisors needs to agree with the client on a pathway to:
• Establish the parents’ (or whoever holds the ‘keys’) broad direction;
• Understand the desired direction of all family members; and
• Collect information and to develop a plan. The plan may involve looking at the productivity and profitability of the farm. The collection of information is sometimes complex and includes:
  ▪ Land ownership – which individuals or entities are the registered owners?
  ▪ Livestock – which individuals or entities are the owners?
  ▪ Machinery – which individuals or entities are the registered owners?
  ▪ What is the financial situation and how is the business performing?
  ▪ Are there any non-farm or underperforming assets (beach house, lifestyle block)?
  ▪ What is the debt/equity ratio?

A farm succession plan may take years to develop and decades to evolve. Much time may be spent considering legal structures. Many people get confused about the use of different legal structures such as trust, partnership, company or sole trader, or their combinations. Once the size of the task is understood then the structures and the number and nature of entities required should be reasonably easy to identify. It must be noted, however, no changes should be made to ownership or structure without accounting, taxation and legal advice.

In preparation for developing a farm succession plan, some essential facts and figures need to be collected which include:
• Who owns what – land, plant, stock
• Assets and liabilities
• Unofficial loans and book loans within family
• Issues of un-paid or under paid wages to family members.

To ensure the drawing up of a good farm succession plan, the following steps should be followed:
• First, ensure that all the advisors are all working for the family as a whole.
• Second, the key family members should meet with the project manager to work out who and when should attend further meetings. Give an outline of the process. Think about in-laws – in or out.
• Third, get the key people committed from each generation – set the ground rules: play the ball not the person and if you are driving the plan do not take sides.
• Finally, it can also be very useful to draw up a genogram as demonstrated in Figure 1. In a genogram, there can be scores of relationships, and attention may need to be given to all of them.

**New thinking for better solutions**

The issues of farm succession will not be fixed by the same thinking which has brought us to the present situation. New thinking will accept that landowners do not have to farm it and farmers do not have to own land. The ownership of land, water, livestock, machinery and equipment can be separated. Labour can be provided on a contract basis. Currently succession occurs when the older generation has had enough or when the younger generation pushes to make it happen. New thinking will allow a bridging period where the older generation can slow down while the business keeps expanding, but the next generation family member is not ready to take over. In these situations some arrangement with an employed manager, share farmer of equity partner can assist in the transition.

Where families start to address succession issues earlier in life they can start to provide for non-farming children with off-farm investments. If parents want to provide for non-farming children a smaller share sooner may be an acceptable outcome. The principle of net present value (less money can be provided now, rather than at some future date and be of equal value) is a useful tool.
The most important factor is to get the issues on the table so they can be discussed by the family as a whole.

Some new tools can also be used to aid farm succession planning. One of them is the Farm Succession Planning Score Card developed by Mike Stephens and Associates in 2005 as shown in Table 1. This score card can be used by any families who have a family member who is going to commence work in the family farm business.

It is important to ensure that all participants in the business, family and non-family, individually, fill in the first two sections of the score card. And that all family members fill in the whole card. If it is only filled in by a few members of the team it is unlikely that the result will be a true reading of the situation. Once all members of the team have completed the card, there should be honest and open discussion about why people have recorded the scores in the way they did. As with any benchmarking, the story behind and the reasons for the number are often more important than the number itself.

The scores themselves are not a “Pass/Fail” situation. For example, a 50% score on the whole card with all the points scored in the first two sections indicates that there has been no investment in succession. There is no statistical rigour to the numbers. The card is a simple tool to promote discussion and point to best practice.

**A case study**

Kirsty McNabb has recently returned home after successfully studying Agricultural Science and completing her bachelor degree. She agreed to come home because her father (Harry) and mother (Sally) had been running the farm, understaffed, and had a job vacancy. The ownership of the farm is complicated because Harry’s father (Ted) still owns most of the land and is keeping his succession plans to himself.

The farm has a mixture of sheep, cattle and crops and Harry is the manager, Sally manages the books and the cattle, and Ted, although supposedly retired, spends most of most days on the farm.

When, at the completion of her last academic year, and immediately before harvest, Kirsty agreed to come home she agreed that they could sort the details out later. When, four months later, nothing has happened, Kirsty searched the web, found the score card and printed five copies.

Kirsty’s next step was to give a copy of the score card to her mother, father, and grandfather and keep two for herself. She secured agreement from each family member that they would fill in the scorecard and return it to her. Kirsty filled in one herself. She also secured agreement (reluctantly) from her grandfather that they would meet to discuss the completed cards and fill in the last one when they had reached agreement on areas where individuals had differed.

The value of the scorecard was highlighted in the discussion.

Sally had started a job description for Kirsty, but Harry disagreed with some aspects of the job as described. Sally had also completed a job description for herself and there was agreement that it covered her situation, but there were no job descriptions for Harry and Ted. There was no organisational chart and Kirsty pointed out that at times she was unsure whether she was reporting to Sally, Harry or Ted and that she found it confusing. They agreed that a chart which clearly showed who was responsible for each area of activity, and reporting lines, would be useful. Sally had letters of appointment for all but one contractor and resolved to attend to that situation.

**The family agreed that unless all jobs are properly described, areas can be neglected or people can start to trip over each other. They also agreed (although Ted grizzled) that they needed an organisational chart.**

The family did not do so well with the second section of the scorecard.

There was no induction process. Salary and payment details had not been agreed or documented. Other benefits, including holidays and days off, were vague. Kirsty pointed out that although she had grown up on the property, she had been away at school and university and there needed to be an agreed procedure in the event of an emergency. She needed to understand the OH&S policies and procedures, and without being demanding about the level of pay and the other conditions she needed to understand what they were.

**Filling in the card gave the family the opportunity to discuss the issues of pay, conditions, induction, OH&S and related issues in an environment of cooperation. Tasks to address the deficiencies were allocated to Sally and Kirsty.**

The Succession Planning section of the scorecard yielded a mixed response.

Kirsty, her younger brother, and her parents (Harry and Sally) have a really good understanding and open and honest communication about the subject. Kirsty knows that both Harry and Sally want to see the farm remain in the family and that her younger brother may also want to farm. The
future ownership aspirations and expectations have been managed well. The difficulty in this section is that Ted still does not say exactly what he intends to do.

_The process has put further pressure on Ted to start to show his hand. The process has highlighted the need to address this area and try to get Ted to tell people what he wants to see happen._

When they got to the last section they agreed that the score should be a C ("Some discussion, but no documentation").

**Concluding comments**

Succession planning is a process, not an event. It is a process which should emphasise the needs of the people and the business. When it is clear what those needs are, the accounting and legal issues can be addressed. Succession planning requires a team approach.

Many families put off succession planning because of external factors such as poor seasons or prices. No business is immune from these external factors. However, the planning process should not be postponed indefinitely because of external factors. Once a plan is in place, the family can wait. When the season or prices are in their favour, the plan can be implemented.

More often it is internal, family issues which inhibit progress. In most families delay causes frustration, which in turn, leads to disharmony or real infighting. Plans which are developed and understood, by the whole family, while the guiding hand of the older generation is present, have a greater chance of success.

**Acknowledgements**

Mike Stephens acknowledges the influence of the University of Western Sydney – Hawkesbury, Heinz & Partners, Geoff Tually and “Options for Change” – RIRDC, in the preparation of this article.
Appendix

Table 1. Succession Planning

<table>
<thead>
<tr>
<th>SCORE CARD FOR FAMILY FARM BUSINESS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Job Description</strong> (Are jobs adequately described and documented?)</td>
</tr>
<tr>
<td>Is there an organisational chart</td>
</tr>
<tr>
<td>A position description for</td>
</tr>
<tr>
<td>• returning family member</td>
</tr>
<tr>
<td>• family members currently on property</td>
</tr>
<tr>
<td>• other permanent staff</td>
</tr>
<tr>
<td>• casual employees</td>
</tr>
<tr>
<td>A letter of agreement for all contractors</td>
</tr>
<tr>
<td><strong>Conditions of employment for all employees including family members</strong></td>
</tr>
<tr>
<td>Is the induction process documented?</td>
</tr>
<tr>
<td>Is the induction process followed?</td>
</tr>
<tr>
<td>Are salary and payment details agreed and documented?</td>
</tr>
<tr>
<td>Are other benefits agreed? (e.g.: Housing, Meals, Vehicle, Fuel, etc)</td>
</tr>
<tr>
<td>Is time off agreed?</td>
</tr>
<tr>
<td>Number of holidays days agreed?</td>
</tr>
<tr>
<td><strong>Succession planning</strong></td>
</tr>
<tr>
<td>Have the expectations of each family member been managed</td>
</tr>
<tr>
<td>Are the needs and aspirations of each person in each generation understood?</td>
</tr>
<tr>
<td>Is the parents' broad direction agreed?</td>
</tr>
<tr>
<td>If the farm is to be passed on, is equity and profitability transparent?</td>
</tr>
<tr>
<td><strong>Succession Plans</strong> – Answer either A or B or C or D</td>
</tr>
<tr>
<td>Full plan documented and agreed</td>
</tr>
<tr>
<td>A All family members have been included in discussions</td>
</tr>
<tr>
<td>All family members have been informed “Excellent”</td>
</tr>
<tr>
<td>B Discussions commenced and progress documented and available “Excellent! Let’s keep the ball rolling”</td>
</tr>
<tr>
<td>C Some discussion, no documentation “Well done! A great start, let’s ensure that documentation occurs”</td>
</tr>
<tr>
<td>D No discussion between generations</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
<tr>
<td><strong>Total sections</strong></td>
</tr>
<tr>
<td>Job description</td>
</tr>
<tr>
<td>Conditions of employment</td>
</tr>
<tr>
<td>Succession Planning</td>
</tr>
<tr>
<td>Succession Plans</td>
</tr>
</tbody>
</table>

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Figure 1. Genogram that can be used in farm succession planning

Andy 1940

Barb 1941

John 1962

Sally

Peter 1987

Kylie 1990

Jill 1964

Kirsty 1990

Sam 1965

Deb 1969

Brendan
The current state of Contract Law in Australia and why it is important for rural managers to understand it

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Abstract: Farmers are business managers and as such they must understand the law or they are likely to fall foul of it. This especially applies to contract law, with which they deal constantly. Contract law is made up of the common law – as the courts have decided it – and statute law – as the state and federal parliaments have enacted statutes which modify the common law. The most important and most recent of the latter is the new Australian Consumer Law.

Key Words: Contract, consumer, unconscionable.

Introduction
This article is addressed to anyone who runs an agricultural business, whether it be broad acre cropping, a sheep and cattle operation, a horticultural or viticultural business or a horse breeding stud, wherever in Australia that business is located.

While your operations may vary in your everyday activities and in your objectives, you will have two things in common with the rest of my audience – first, you are aiming to make a profit and second, you are intimately connected with a large network of laws, state and federal, which, whether you like it or not, control many aspects of your operation and your relations with your neighbours, competitors and workers.

I would not presume in this short article to be able to explain all these laws, but I do encourage you to find some way of researching the particular laws which relate to you, which most of you have probably already done. Establish and cultivate contacts in your local Department of Primary Industry (by whatever name it goes in your state), in your local Department of Environment and Water, in your local Work Cover Authority and Department of Industrial Relations – these contacts will be invaluable in updating you with regard to changes in the law.

The same applies to your own particular Professional Association – Farmers, Horticultural etc – as contacts in these organisations should help you a lot.

To the above you should add your local solicitor.

Researching Federal and State Laws
I make these points because you must be aware of the laws under which you operate your business – ignorance of the law is no excuse, they say, and, though trite, this is usually true. This may mean a little research, but luckily the Internet has made this much easier than it used to be.

You are probably aware that all federal, state and territory legislation (that is, Statutes and Regulations), is available on the Internet - federal law at www.comlaw.gov.au, and also at www.austlii.edu.au. The former is operated by the Commonwealth Attorney General’s office and the latter is an independent professional website.

For state and territory legislation use this website: www.legislation.nsw.gov.au – simply change the 3 digit jurisdiction indicator for the one you want. Thus for Queensland law go to www.legislation.qld.gov.au, and so on.

I don’t necessarily recommend rushing to research an Act of Parliament every time you have a problem, but occasionally it is good to know precisely where to find what the law says.

Business of any sort involves contracts
An understanding of Contract Law is very important to any business operator.

A contract is a promise or a set of promises between two or more parties for the breach of which the law will provide a remedy.

Does a contract have to be in writing? No, and the majority of contracts are verbal. They are none-the-less valid for not being in writing so long as no dispute arises about what the parties actually agreed.

What follows from this is that the more important the contract, the more necessary it is to have it in writing.

Generally speaking, a contract in writing must contain ALL the terms, and it cannot be added to verbally. It can of course be added to in writing if both parties agree to the addition, and with modern word processing facilities this simply means amending the original written contract, printing out a new
When you sign a written contract

You will be bound by all the terms in it whether you have read them or not. Your signature implies that you have read the contract, understood it and agree with all the terms.13

It is therefore extremely important that you never sign a contract until you have read it thoroughly.

If, however, unfair pressure has been brought to bear on you to sign the contract, you may be able to avoid being bound by it. Such unfair pressure is called "unconscionable conduct" and can include:
- Not being given time to get professional advice on its content, and
- The other party taking advantage of a disadvantage of yours of which they are aware.

Such a disadvantage could be a language problem, a mental disability, illness, or education.

We will look at unconscionable conduct in more detail below.

Needless to say the reverse applies – you should not use such conduct to force another person to sign a contract with you.

The new Australian Consumer Law

Concerned at the number of different federal, state and territory laws which dealt with fair-trading and consumer protection, the Australian Competition and Consumer Commission and its state and territory counterparts have developed over the last few years this new body of law which came into effect on 1st January 2011 and "replaces previous Commonwealth, state and territory consumer protection legislation".14

For unknown reasons this important piece of legislation is not an independent Act but is contained in a schedule to the Competition and Consumer Act 2010 (Cth).

It is the inclusion in this new law of unfair contract terms which make it important to introduce it here.

Unfair terms in a contract

The new Australian Consumer Law (ACL) brings in the concept of unfair terms in a Standard Form Contract. This is a written contract, used by a business for all its clients, and which binds a consumer when they sign it (other than as we have seen above).

It is the sort of document which efficient businesses use and amend to reflect the terms of each contract they are involved with so they do not have to reinvent the wheel for each new agreement.

Often if you sign such a contract you are not given a chance to negotiate the terms. If, however, such terms are unfair, a court may decide that they do NOT bind you as a consumer.

So what makes a term unfair?

Under the ACL a term is unfair if:
- it could cause a significant imbalance between your rights and obligations and those of the business,
- the term is not reasonably necessary to protect the legitimate interests of the business,
- it would cause you detriment (financial or non-financial) if the business tried to enforce it,
- the term is not presented clearly and expressed in reasonably plain language,15
- any term fails to meet these requirements you should discuss it with your legal advisor to see if you can avoid being bound by it. S.25 of the ACL gives a number of examples of unfair terms,
- a term permits, or has the effect of permitting, one party (but not another party) to vary the terms of the contract,
- a term permits, or has the effect of permitting, one party (but not another party) to terminate the contract, or
- a term limits, or has the effect of limiting, one party’s right to sue another party.

Note that these provisions do not apply if there is no standard form written contract involved, or if you are not a consumer.

It is important to realise that you do not need to rush off to a court to have a term in a contract declared "unfair" – the very fact that you recognise what may be an unfair term could enable you to persuade the business with which you are dealing to remove it from the contract or vary it in your favour.

Let's now look at unconscionable conduct in a little more detail.

Contracts - unconscionable conduct

13 Toll Pty Ltd v Alphapharm Pty Ltd &Ors [2004]HCA 52

14 The ACL – Consumer Guarantees – a guide for businesses – ACCC and others. Introduction p.2

The common law of contract, that is, the law as the courts have interpreted it over the last 200 years or more, has recently been supplemented to a large degree by statute law. Much of this happened in the last quarter of the 20th century and this has recently been summarised in the new ACL (see below for more details).

Unconscionable conduct – taking advantage of another person's known weakness to get a contractual advantage for yourself - has been prohibited for a quarter of a century or more – first under the Common Law and later by part IVA of the Trade Practices Act. This was repealed in late 2010 and unconscionable conduct is now covered by part 2-2 of the ACL. The wording is almost exactly the same as before. Section 21 lists examples of what a court would consider if such conduct is alleged:

(a) the relative strengths of the bargaining positions of the supplier and the consumer; and
(b) whether the consumer was required to comply with conditions that were not reasonably necessary for the protection of the legitimate interests of the supplier; and
(c) whether the consumer was able to understand any documents relating to the supply or possible supply of the goods or services; and
(d) whether any undue influence or pressure was exerted on, or any unfair tactics were used against, the consumer; and
(e) the amount for which, and the circumstances under which, the consumer could have acquired identical or equivalent goods or services from a person other than the supplier.

Examples of where unconscionable has been found by a court include:

• where one party failed to give the other party time to consult a lawyer before signing a contract;16
• where one party took advantage of the other’s alcoholism;17 and
• where a bank knew that the consumer couldn’t understand business English but made no attempt to find an interpreter.18

You will note that the Unfair Terms part of the ACL and the Unconscionable Conduct part overlap a little. This is to your advantage as a consumer.

If you are not a consumer, as defined below, and the other party to your contract has engaged in unconscionable conduct against you, you will have rights under the common law (in other words because of previous court judgments), but not under the ACL.

So what is a consumer?

The definition of consumer in the ACL replaces all former definitions in the Trade Practices Act and the state Fair Trading Acts. Under the ACL, you are a consumer:

• if you buy goods or services for less than $40,000; or
• the goods or services were of a sort normally acquired for personal or household use or consumption; or
• the goods consisted of a vehicle or trailer acquired for use principally in the transport of goods on public roads.19

You are NOT a consumer if:

• you buy goods for the purpose of re-supply; or
• for the purpose of using them up or transforming them, in trade or commerce:
  in the course of a process of production or manufacture; or
  in the course of repairing or treating other goods or fixtures on land.

Looking at some examples might clarify this a little.

• Example 1: You buy $20,000 worth of hay to feed you stock. You are NOT a consumer because you bought the hay for the purpose of using it up in trade or commerce (your farm).
• Example 2: You buy $50,000 worth of concrete, tiles, fencing and fibreglass for your new swimming pool, You ARE a consumer because all the goods are for private and domestic purposes.
• Example 3: You buy a new truck for $100,000 for carting stock, hay and other farm products to market or to other properties. You ARE a consumer because the truck is principally for the transport of goods on public roads.
• Example 4: You contract with a painting firm for paint and its application on/in your homestead. The contract for goods and services is worth $65,000. You ARE a consumer because the goods and services are for personal and domestic purposes.
• Example 5: You arrange for a construction firm to carry out repairs and refurbishment of your shearing shed. You

16 Commercial Bank of Australia v Amadio (1983)151 CLR 447
17 Blomley v Ryan (1956)99CLR
18 See 4 above. Same case
19 The Australian Consumer Law s.3
are NOT a consumer because the goods and services provided are to be used in the course of repairing or treating other goods or fixtures on land.

Does it matter if you are not a consumer?
It will not affect the validity of your contract, but you will not be able to take advantage of any of provisions of the ACL if you are not a consumer. In your business life you will alternate – some contracts you enter into will be contracts where you are a consumer, and in others you will not be a consumer.

In some contracts you will not be a consumer, but the other party will be. In other contracts – business to business contracts – neither party will be a consumer.

What this means is that the ACL will only cover the consumer – but non-consumers have rights also. Discuss this with your solicitor if you want clarification.

The Australian Consumer Law (ACL) – Consumer Protection
This law came into force in all Australian states and territories from 1st January 2011 but although the explanatory guide explains that it “replaces all previous Commonwealth, state and territory consumer protection legislation”, this is not strictly the case. Many state laws – such as the Sale of Goods Acts and in NSW the Contracts Review Act – are still in force, even though much of their content is already covered in the new law. However, they will probably disappear when the review process of the ACL is completed by the end of 2011.

What else is there in the ACL?
We have looked at Unfair Contract Terms and Unconscionable Conduct, so what else is there that rural business operators should understand?

Some of you may remember s.52 of the old Trade Practices Act – one of the most powerful and frequently used parts of that law. It still exists as s.18 of the ACL and is worth setting out in full.

This section states: “A person must not, in trade or commerce, engage in conduct that is misleading or deceptive or is likely to mislead or deceive.”

That is fairly straightforward, but you must understand that it covers not only deliberate misleading conduct but also conduct which misleads unintentionally, and also covers lack of action or explanation where such action should have been taken.

Such conduct often takes place in pre-contractual negotiations but can also be found in the performance of a contract, and if proven, will give the innocent party grounds for legal action against the misleaders/deceiver.

A case law example may help explain this. Company C was hoping to sell a restaurant business, and advertised it. They said it would seat a certain number of people, but this number exceeded their licensed seating. During the course of negotiations they provided profit figures to the prospective purchaser, and these too proved to be an exaggeration. The sale went through but the purchasers sued for a substantial sum which the federal court agreed had been the result of the misleading and deceptive conduct of the company.20

In another case a company was marketing a product called “The Ion Mat” which, the company claimed, emitted negative ions which would “reduce stress and assist in reducing cancer causing cells” and would cure a number of other ailments. In a case against the company by the ACCC, the Federal Court found that all the claims were false and ordered the company to cease advertising and selling the Ion Mat.21

This section (s.18) does not carry a penalty, but only provides ammunition for legal action.

All the other consumer protection sections which we are about to mention, and the provisions for unconscionable conduct, carry a maximum penalty in some cases of $1.1 million if the offender is a company or $220,000 if the offender is not a company.22

So this legislation has teeth if a court decides to use its powers.

Unfair practices
Part 3.1 of the ACL is entitled “Unfair Practices” and lists a number of these which protect the consumer against an unscrupulous supplier of goods and services, including the sale of land. These have been taken almost without change from Part V of the Trade Practices Act. The Misleading and Deceptive conduct provisions are expanded in this part, to include specifically (for example) employment. It is an offence under the ACL to engage in conduct which could mislead persons seeking employment about the availability, nature, terms or conditions of the employment, or any other matter relating to the employment.23

As an example, a company advertises a position, and responds to an applicant by

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22 ACL s.224.
23 ACL s.31.
offering them an interview. The applicant accepts and attends the interview but is unsuccessful. They discover that prior to the date of their interview another person had already been appointed to the position.

This would appear to be a breach of the ACL as when they interviewed the applicant there was no longer a position available. This could make the company liable to a prosecution and a fine of up to $1.1 million.

This is an example of the previous s. 52 TPA, now s. 18 of the ACL, applying to a "business to business" dispute and not involving a consumer.

Other unfair practices include pyramid selling, bait advertising, claiming payment for unsolicited goods or services, and use of harassment or coercion in relation to payment for goods or services.

It is not either possible or desirable in an article like this to go into great details about the provisions of the ACL, but one thing should be of interest. Have you ever called in a tradesman to do a major job and on completion received a one line bill? If, like most of us, you have probably wondered how the bill was made up but been not too keen to ask in case the tradesman got cranky.

The ACL solves this for us. S.101 states if services are supplied to a consumer, the consumer may request that the supplier (of services) give the consumer an itemised bill that:

(a) specifies how the price of the services was calculated; and
(b) includes, if applicable, the number of hours of labour that related to the supply of the services and the hourly rate for that labour; and
(c) includes, if applicable, a list of the materials used to supply the services and the amount charged for those materials.

The supplier must provide such an account within seven days or face prosecution and a penalty of $15,000 if they are a company or $3,000 if they are not.

Since we all spend a great deal of our time as consumers and since the ACL is a long and complex, but extremely important, piece of legislation, it would be well worth finding out from your nearest Office of Fair Trading, from the Australian Competition and Consumer Commission or from your own professional association whether any familiarisation courses on the ACL are available in your region, and if so try to attend one.

I think you will find it well worth your while.

Summary

The points which have been highlighted in this article are

- An understanding of contract law and especially the significance of signing a written contract is important to every business person.
- It is important in every contract to know if you are a consumer or not.
- If you are a consumer, the Unfair Contract terms of the ACL may protect you.
- Be aware of what constitutes Unconscionable Conduct and learn to recognise it – and avoid it yourself.
- Try to learn about the Australian Consumer Law and how it can protect your interests.
Changing business environment: implications for farming

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Abstract. The natural, technological, economic, political and social environment in which farmers farm constantly changes. History has lessons about change in agriculture and about farmers coping with change, though the future is unknowable and thus always surprising. The implication for farm operation is to prepare, do not predict.

Keywords: Preparation, prediction, farm management, uncertainty.

Introduction

The changed future will come to farmers in Australia a day at a time and, as always, it will be shrouded in ‘clouds of vagueness’ (Arrow 1992) until it unfolds about them. Farmers will be making decisions about choices in their changed future to try to achieve their goals under conditions of limited information, risk and uncertainty. These decisions will be of an operational (day to day), tactical (within seasons and years) and strategic (2-5 years, 5-10 years) nature.

In deciding their choices, farmers will have access to more information than ever about nearly every aspect of their farming systems and commodity and financial markets. But, lack of knowledge and uncertainty will remain the main challenges. Despite the mountains of new and more timely information, much about the present will remain poorly understood and misinterpreted, e.g., knowledge about key, response functions. The main challenge for farmers will be to manage inevitable uncertain events in partially understood farm systems, while doing some things much as they have always done and doing other things in situations and ways that are not even imagined at present.

As suggested in papers in this volume, trends in major changes beyond the farm will continue apace: concerns of an increasingly wealthy population about the natural environment will increase; some water in the MDB will be diverted from irrigation agriculture to the natural environment; private investment in agricultural R & D&E may increase, while the need for the highly rewarding but slowing down public investment in agricultural R & D&E will be greater than ever. As well, in the medium term, the Australian mining boom will exacerbate existing pressures for structural adjustment in agriculture. Growth in world population, along with growth in world income, indicates potential growth in aggregate world demand for various agricultural commodities. The demand side of farming will see much action. The detail about what will happen on the supply side remains unknown: which farmers, whereabouts in the world, producing what products in what ways with what new methods, to meet the growing demand – remains unknowable. Evidence that world food supply has doubled several times in recent decades give sound reason to expect that the next required doubling of world food supply by 2050 can be achieved, but little is sure about the ways this will be done.

Looking Backward: the past as prologue

In twenty years of farming in Australia, much can happen. Before thinking forward about farming from 2012-2032, it is instructive to think back, to say, 1992, 1972, 1952, 1932, to recall how different was the farming environment of each of these twenty-year periods. It is ambitious to try to make the case that the difference in the rate of change in any of these arbitrary periods of time is any more or less different than any other time. In every time the rate of change in the environment dealt with by farmers is momentous.

In the 1930s, horses were replacing tractors amidst the Great Depression, with World War Two brewing. Low income problems in farming, a result of small farm, post-World War One closer settlement schemes, were rife. Wartime economy, major drought, shortages of agricultural commodities and high prices, occurred in the 1940s. The Rural Reconstruction Inquiries into the state of affairs in farming, led by Sir Samuel Wadham, were instigated. The 1950s and 1960s saw good seasons and prices, rapid developments in agricultural science, fixed exchange rates, massive immigration and consistent strong economic growth around the world, closer land settlement opening up new agricultural lands, emerging opportunities for pasture development, bigger machinery, bulk handling of grain. From the mid to end of the 1960s farmers battled widespread serious drought, while small dairy and wheat farmers struggled with low commodity prices and the high overhead costs of small farms. Commodity supply and low income problems led to the marginal dairy farm reconstruction scheme and wheat quotas.

Farming in the 1970s was characterised by upheaval in many industries (Makeham et al. 1979). There were oil price shocks, runaway inflation, high interest rates, market collapses
and temporary price spikes, a mining boom causing high exchange rates, tariff reforms. In 1974 the wool Reserve Price Scheme (RPS) was introduced. Following the Marginal Dairy Farm Reconstruction Scheme of the late 1960s, the 1970s Rural Adjustment Scheme was introduced. The aim was to speed the process of agricultural adjustment. Intermittent ‘crises’ in various industries were met with various poorly thought out ‘stop-gap’ measures tried to help struggling farmers to ‘carry-on’ (Makeham et al. 1979). In the late 1970s, Victoria’s 30,000 dairy farmers were being paid $5 for each of their cows they shot.

Widespread serious drought in 1982 was followed by a big wet year. The exchange rate and financial system was deregulated. Growing national balance of trade deficits led to a collapse of the value of the $A. Well into the 1980s, the operators of the wool industry reserve price scheme set the price of wool way above world market prices. Unsurprisingly, demand collapsed while supply grew rapidly. One hundred and eighty million sheep, compulsive woolgrowers all, filled warehouses around the nation with wool no-one wanted to buy, except the woolgrowers themselves. The wool RPS, one of the greatest financial debacles and public policy failures in Australia’s history, built a stockpile of 3 million bales of wool worth $2 billion which hung over the industry for the next decade. Australia’s once grandly significant wool industry was reduced almost to cottage industry status and has only partly recovered. On farms, technological change continued apace; minimum tillage emerged as a promising innovation; new weed control chemicals became available; grain feeding of dairy cows became standard, as did growing oilseed crops in cereal rotations. Cropping machinery and farm size continued to grow.

The 1990s started with economic recession, high interest rates, followed by gradual economic recovery to a sustained period of growth. Computer and telecommunication technology became regular parts of daily farm life. Precision machinery uses and electronic identification of animals were introduced. Rapid gains in genetic potential of beef, pigs and poultry occurred. The dairy industry was fully deregulated in 2000 and the wheat industry was deregulated by 2005. This spawned a host of new grain marketing and price risk management opportunities. A decade of drought and widespread shortages of irrigation water followed through to 2009. The mining boom resulting from high and sustained growth in the Chinese economy created the highest exchange rates for Australian farmers in 40 years.

Since 2000 rapid growth of emerging economies in China, India, Russia and Brazil has created world-wide growth in demand for protein. At the same time ill-advised policies subsidising biofuel production has diverted significant food and animal feed grains away from food and feed markets. Finally, in 2011 the world population reached 7 billion people on the way to 9 billion people by 2040. This growth in population means farmers, Australia and everywhere else in the world, face the biggest challenge they have ever faced to increase the supply of food in the world by 70 per cent over the next 30 years. This aim will not be helped by the reduced inclination for investment in agricultural research and development in wealthy countries.

Awareness of the possible precariousness of the match of world food supply to growing food demand was heightened in 2007 when droughts in both hemispheres of the world caused stocks of grains to reach record low levels, which along with diversion to biofuels and the Global Financial Crisis, causing a flight of capital into soft commodities, plus record high oil prices, causing inputs costs to rise, resulted in a large spike in agricultural commodity prices. As always, world-wide farmers responded: crop plantings increased and world supply and stocks recovered rapidly, and prices rapidly reverted to mean trends.

Consumers became more demanding about agricultural product quality. Public concerns about the state of the natural environment and the welfare of animals, concerns that have been growing strongly since the 1980s, grew apace in the 2000s. Growing concern about carbon dioxide pollution and medium to long-term prospects of future warming temperatures, leading to changing rainfall quantities and patterns, including increasing volatility of weather, has characterised the past decade.

Eternal verities

Successful farm business in coming decades will continue to face pressures that raise their real costs of acquiring and managing resources. This will occur because low income elasticity of demand for food means that growing national incomes end up as non-agricultural demand. Resources of land, labour, capital and management are competed away from agricultural uses. Prices farmers receive for their products will continue to be volatile, as they have always been, as supply fluctuates with weather and demand fluctuates with economic cycles. At times, rising real costs will coincide with declining real prices received, and farm incomes will be squeezed. At times, there will be the happy coincidence of good seasons, good prices and good returns to capital.
The imperative for farm owners and managers to continue to adopt new technology and both intensify and extensify their farm systems to maintain profit in the face of rising real costs will remain the main game. Farmers will use new, improved and more effective variable inputs that will contribute more output for the same or lower costs, and farmers will increase output relative to fixed costs, thereby reducing average fixed costs. One inevitable result of these actions: fine-tuning existing operations and expanding business size, changes the nature and complexity of farming and changes the exposure of the business to pressures from risks of volatility, and increases the need for flexibility in farm systems.

So farming, always the hard way to make a living, will become more complex, and for this reason, will be an even harder way to make a living. Farm decision makers will need to process more information than ever, and be operationally more adroit than ever. More and better information will be helpful in meeting the challenge of decision making under risk and uncertainty, but cannot change the risk and uncertainty affecting the farm business components, about which decisions are being made.

Decision makers still have to try to make good bets. The key to good betting is imagining the future with rigour: assembling relevant information in as complete a way as possible; being transparent about what is knowable and known and what is not knowable or known, and what is assumed, in the decision analysis and decision-making processes; and honestly facing the brutal facts of the business, with and without the potential change. Imagining the future with rigour means exploring in a logical, informed and rational way possible alternative sets of future circumstances – these different futures can be different changes or different timings of implementing the one change.

 Implicit in the farm management process is a well-defined set of realistic, achievable goals. Setting goals involves imagining the future: visualising how situations might look at some defined future time and determining the preferred situation(s). Once preferred situations are determined, where we are trying to get to, the feasibility of getting there and how to get there become the questions.

Farmers invariably identify their major challenges as managing increasing complexity (Kingwell 2010), including successfully incorporating new technology into their systems and increasing the size of their business, as well as managing labour profitably and arranging successful succession. These challenges always rate highly because they are tasks directly and largely under the control of farmers. These are also areas in which there is growing knowledge and specialist expertise available. Obtaining the help of experts in specialist fields remains one of the investments with the best returns farmers can earn.

Another challenge facing Australian farming is having to operate in a society in which increasingly farming is a foreign country. The profound ignorance of farming of well-off urban dwellers cannot be exaggerated. The consequent farm-urban disconnect has serious implications for agriculture. Public concern for the natural environment and the welfare of farm animals increasingly affect what farmers do and how they do it. Such demands, including demand for alternative uses and values of natural resources, grow as societies become wealthier.

**Looking forward: the future is always surprising**

Farming has always been about managing change. As ever farmers will face the challenge of incorporating new technology into their systems, and of making sound decisions about changing their businesses in response to changes in the natural, technological, economic, political and social environments in which they operate. Predicting the state of these environments is fraught: surprise will rule.

In 1950 it would have been folly to try to predict the detail of the changes in conditions of demand and supply that make up the environment of farming today; or the changes in populations and attitudes to farming; or the mix of recreational and commercial farming; or farm scales that exist around Australia today. While the comparative advantage of individual farms at any time in any locale determines the forms and performance of economic activities, comparative advantage is a dynamic concept. For instance, the nature of economic activity and the detail of operations of firms operating currently in any district or wider region are vastly different to what was happening in the different circumstances of the same locales 30 years or 50 years ago or more.

However, 100 years ago, as now, there were farm businesses run well and operating efficiently. This means earning returns on capital, considering risk, that compare well with the risk and earnings of alternative uses of capital in the economy. At the same time, there were many farm businesses, poorly run, that earned far lower returns on capital. (Only sometimes could the operators claim that they already knew how to farm better than they were inclined to do). In 50 and 100 years time, the same will be the case: a
proportion of firms combining land, labour and capital in an area will earn returns commensurate with the risks and returns of alternative investments, some firms will earn much less.

What is known, and will not be surprising, is that currently profitable farm systems will not be the future profitable farm systems. The question though is not one of comparing the future with the current. When contemplating the futures, the right question is ‘How does my business look following a change to the farm system in the expected changed future conditions, compared with how my business looks without the change to the farm system in the expected changed future conditions?’ The status quo is not a future option.

Future growth in productivity

Changes in productivity are measured by changes in the physical amount of output that results from changes in the physical amount of the inputs used in production. An increase in productivity from one year to the next means a firm produces the same output in the two successive years with less measured inputs in the second year, or produces more output in the second year with the same measured inputs as the prior year. Investment in R, D&E provides the new technology that enables farmers to move their production systems onto new production functions, i.e., increasing technical efficiency or productivity. Farmers thus face two main challenges: managing their existing system profitably (allocative efficiency) and changing their system by implementing new technology (moving onto new production functions with improved input:output ratios). They are constantly doing both these things. The main sources of improvements in physical input:output relations - growth in productivity in farming - are:

- Using the given set of resources better (technical efficiency)
- Changing scale of operations and getting output benefits from the scale effects of inputs (scale benefits)
- New technology that changes quantity of inputs and outputs and improves technical efficiency by producing more output per unit of input in farm systems (technical change) (Coelli et al. 2005).

A problem in public discourse is that different notions of the terms “production”, “productivity” and “profitability” are used by different participants, often in the same conversation. Production is total output, either in gross value or total quantity. Productivity is a ratio of measured quantities of inputs and outputs, but not including all inputs. Profitability is the result of all of the amalgamated effects of technical relations between all inputs and outputs, how the inputs are combined, and including the effects of changes in prices received and paid. Profitability is what matters to farmers running businesses on a year-to-year basis: it provides the wherewithal to reward capital invested and supply savings for reinvestment.

Confusion reigns. A farm consultant or scientist may be talking about partial technical efficiency (physical output/a single physical input), and thinking they were saying something about profit; economists may be talking about changes in Total or Multi-Factor Productivity (value of all output/value of many but not all inputs) averaged across an industry, and over time, while recognising that it is the combined effect of changes in productivity and changes in the prices received and paid on individual farm business which is what matters. Someone interested in investment in R, D&E might be mistakenly thinking that measured changes in industry productivity over time can be attributed to particular investments and indicate where good future investments can be made in R, D & E. (In practice, analysis of prospective investments in agricultural R, D & E have to be made on case-by-case analysis of potential gains in farm systems).

The net effect of improvements in physical input:output ratios is to reduce the average and marginal cost per unit of output and/or increase the value per unit of output, thereby maintaining or improving profit in the face of rising real costs of inputs and declining real prices of output. Achieving economic efficiency directly helps farmers achieve their goals, such as making profit, paying their bills, growing their wealth and managing risk. Output per unit of input is relevant and helpful to these ends, though the principle of diminishing marginal returns means that the level of total production that gives maximum technical efficiency – maximum average product per system or per individual input - is not the same amount of production as that which gives maximum economic efficiency. Hence, some confusion: increasing the quantity of inputs used in order to increase annual profit can reduce measured average technical efficiency/productivity.

Change in productivity as analysed and reported are measures of change in quantity of output relative to change in quantity of inputs used, on average, across samples of farms in an industry. Though maintaining and improving productivity is one key to maintaining and improving profit, changes in measured industry productivity do not indicate what is happening to profit at an individual farm level.

Measures of productivity over the long run tell something about resource use in agriculture, aggregated across many firms. This measure can be compared with what competitors are achieving and indicates something about changing relative competitiveness. Changes in productivity also tell something about the technical capacity of farm businesses in a sector, on average, to offset rising real costs of inputs or declining real prices of outputs (worsening farmer terms of trade). Also, there is likely to be a relationship between investments in agricultural R&D&E in a prior time and improvements in measures of productivity ten to thirty years later.

From the viewpoint of understanding about prospective changes in industry structure or potential for farms in particular industries to grow and prosper, or struggle and decline, or how well farmers are farming, or the welfare of farm families, there is no substitute for analysis of the profit performance, balance sheet and debt servicing capacity of individual farm businesses.

Potential impediments to productivity growth that will restrict continued farm profit in the face of rising real costs over time are:

- Insufficient capital supplied for investment in agricultural R&D&E,
- Poor investments in specific areas of agricultural R&D&E,
- Insufficient supply of agricultural scientists to conduct the needed R&D&E, and
- Barriers to adjustment to farm intensification and extensification.

These potential impediments to future productivity growth and maintenance of profit are all matters that are, to varying degrees, within the influence of both the private and public sectors of the agricultural and general economy. For instance:

- Farmers could contribute more resources to agricultural R&D&E through their publicly matched levies to RDCs,
- The public could contribute more resources to R&D&E, and to attracting and training agricultural scientists,
- The public could remove and reduce barriers to farm change, such as subsidies that enable the continued survival of farm businesses that are poorly run, unprofitable and have no future,
- The public could rationalize land use planning regimes that inhibit profitable deployment of resources, and
- Public agricultural R&D&E investments concerning hotter and drier future climate, and rougher weather, could focus primarily, and to a greater extent than at present, on supplying technical and risk information that will enable private business-people in the distant future to make well-informed decisions about running their business.

Increased focus on researching the science of future farming conditions will be more beneficial than the high-level soothsaying that comprises much prognosticating about social and economic forms of a future carbon-constrained world.

**Farming with a price on carbon**

For farm businesses, changes in weather and in climate are economic problems. The scientific and the social cannot solve the problem. Economic solutions encompass the scientific and the social. As a price on carbon becomes established in Australia and increasingly around the world, farmers and consumers of their output will increasingly incur some of the costs of carbon dioxide emissions produced by farm activities and by the activities of the producers of inputs that farmers use. Some opportunities for income earning from sequestering carbon too may arise in some situations, albeit of a limited nature. Sound information about mitigating emissions from farm activities and changing systems in the face of higher carbon-related costs will be vital. Supply of credible information about carbon in farming systems is increasing on a daily basis.

Physical capacity for additional sequestration of carbon is limited, while the additional costs incurred by locking-up carbon include both the opportunity cost of the land use as well as the extra nitrogen and phosphorus that is locked-up along with extra carbon in direct proportions, and which exceed the value of the carbon (Passioura et al. 2008). Further, extra carbon sequestered in soil increases emissions of the greenhouse gas nitrous oxide, especially under high rainfall conditions. Farmers will find the opportunity cost of locking away carbon in soils is high and the returns over 100 years are low. Carbon sequestration in soils will not be a widely attractive proposition in most farming situations (Eady et al. 2011). Forestry has more going for it in this regard, in areas where it rains plenty and trees grow well, even after allowing for risk of fire and disease (Eady et al. 2011).

In the context of the cost of carbon prices on farm systems, when allowance for future productivity growth is incorporated in analyses, the impost of carbon-related charges on farm system cash flows appear potentially modest. For instance, these costs pale into insignificance compared to factors like a change in exchange or interest rates, or
debts levels, or a decent and timely fall or absence of rain.

While much focus of carbon costing is on ‘pass back’ to farmers in the first instance, as agricultural supply world-wide incurs additional costs associated with carbon, and with long-run supply more responsive than long-run demand for agricultural commodities, consumers will bear the larger share of the cost of carbon. Taxes are not paid fully where they are laid.

The main relevance of pondering about future farming in a carbon constrained economy with a warmed climate is in changes in risk associated with the major strategic decisions the operators of farm businesses will be making. The operational and tactical risks will be managed as now, on a day-to-day, season-to-season basis. Research that focuses on risk associated with rare events that have big impacts will prove productive.

There is also a mismatch between the needs for farmers to farm well on a day-to-day basis, responding to weather conditions, and the needs of science and of policy understanding about climate change over 30, 50 70, 100 years. Long-run changes in averages over large geographic areas have little meaning to particular farm systems dealing with fluctuations around artificially contrived ‘average’ situations which never actually exist.

**Farm management analyses**

The whole farm approach, allied to the principle of diminishing marginal returns to extra inputs, with a proper appreciation of profit, finance, growth and risk, will still be the only valid approach to farm management economic analysis and farm decision analysis. Without doubt, lacking this farm economics framework, flawed single-input focused technical, partial, average methods of thinking about the management of farms will continue to be used in farm advisory work by agricultural scientists and consultants. There is much scope for progress to be made in the farm advisory and research investment fields.

In a methodological sense, risk analysis and risk management is progressing. Tools for analysing risk in decision making are improving. Straight-forward probabilistic analysis in budgeted outcomes and methods of scenario analysis are useful improvements. Certainty equivalents and their alignments to standardised estimates of low, medium and high risk aversion is now straight-forward using stochastic efficiency with respect to a function (SERF), and standard investment analysis criteria of IRR and NPV will be refined by analysis of real options and their value. Risk tools such as weather derivatives may develop into operational management aids; increasingly unwanted price risks will be sold. Improvements to decision analysis will better inform decision-makers in the complete, transparent and honest consideration of risk, used in forming their judgments about how much to bet on which opportunity. There remains much farmers have no control over. Consequently, a prudent strategy for business management is to manage well those elements, and risks, over which there is some control. Prepare, don’t predict.

**Concluding comment**

Investment in agricultural R, D&E makes possible improvements in agricultural productivity that over time maintain and improve farm profitability. Removing impediments to farmers coping with change will help them. So too will wider understanding of the farm economic framework for farm analysis and decision analysis, allied to more and better economic and technical information that assists farm decision making about strategic changes to farm systems, under greater uncertainty than ever.

**References**


