EVALUATIONS IN 2003 OF FIVE AREAS OF INVESTMENT IN R&D BY NSW AGRICULTURE: SUMMARY

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NSW DEPARTMENT OF
PRIMARY INDUSTRIES

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Abstract: In 2003 the economic, social and environmental impacts of five areas of research and extension where NSW Agriculture has made significant investments were evaluated. These investment areas included net feed efficiency in beef cattle; the management of temperate weeds in temperate pastures; conservation farming in the northern NSW cropping zone; wheat breeding in NSW; and extension in water use efficient technologies. The benefit cost analyses were conducted over the period from 1980 to 2020. For these five project areas NSW Agriculture invested $114m, including some support from industry. The industry returns totalled $1311m giving an average benefit-cost ratio of 11.5, ranging from 4.5 to 22.2.

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Executive Summary

In 2003 Program Economists in the former NSW Agriculture[1] evaluated the economic, environmental and social impacts of its investments in research and extension activities related to its:

- wheat breeding program based at Wagga;
- advisory programs in water use efficiency particularly those promised to irrigators as part the water reform process in NSW;
- research into breeding for net feed efficiency in beef cattle;
- research and extension in conservation farming in the Northern cropping areas; and
- research and extension in annual weeds (*vulpia*) in pastures in the temperate zone.

This evaluation process is expected to continue with five areas of investment analyzed each year. Detailed reports for each investment area will be available on the web at: http://www.agric.nsw.gov.au/reader/10550.

In each evaluation some assessment was made of environmental and social impacts although in a qualitative rather than a quantitative manner at this stage. Some environmental and social impacts, which may be positive or negative, are captured in the measures of economic impacts discussed below. However some environmental and social impacts 'spillover' beyond the producers, processors and consumers that make up an industry to the broader community. These we have not been able to value and hence any judgment about the merits of the investments from a public viewpoint involve a necessarily subjective weighing up of economic impacts, quantified to some degree, against qualitative assessments of environmental and social impacts on the community. This is not a new choice problem although perhaps social and environmental impacts may now be valued more highly.

Greater effort was focused on estimating the economic impacts in terms of productivity gains at the farm level. These productivity gains were valued and related to the investments made by NSW Agriculture. The size of investments by NSW Agriculture ranged from $8.7million to $52 million in present value terms in 2002 (where the investment period was different for each project). The net present value (NPV) of the flow of benefits ranged from $68.2 million to $568 million . Hence benefit-cost ratios (BCR) ranged from 4.5:1 (water efficiency project) to 22.2:1 (*vulpia* in temperate pastures). For these five project areas NSW Agriculture invested $114m, including some support from industry. The industry returns totalled $1311m giving an average benefit-cost ratio of 11.5.

Further, the small sample of five evaluations limit any attempt to make general statements about priorities and resource allocation in NSW Agriculture. The small sample means there is little information about the opportunity cost of these investments. As the process of evaluation continues over the next few years, the bank of information about the impact of investments by the NSW Department of Primary Industries will increase and hence it will become more useful in priority setting and resource allocation processes.

[1] This work was done prior to the formation of the NSW Department of Primary Industries (on July 1, 2004) through an amalgamation of NSW Agriculture, NSW Fisheries, State Forests of NSW and the NSW Department of Mineral Resources.

With these qualifications in mind, it would seem that the former NSW Agriculture earned a moderate to high rate of return from the five areas of investment evaluated in 2003. Many of the benefits from these investments are likely to have been captured by the industry rather than the community but in all cases there are likely to have been significant environmental impacts that have benefited the community. Any judgment about how benefits are shared between industry and the community is subjective because we have been unable to quantity all benefits. Nevertheless in our view, in most instances, there has been some divergence between the proportion of benefits and costs shared by industry and the community and hence in the future the NSW Department of Primary Industries should be seeking a greater level of industry funding in all areas except for the water efficiency program which is presently funded by a Treasury enhancement. If industry chooses not to increase its level of research then the Department needs to confine its commitment to those components of investment areas where the flow of community benefits is expected to be high.

1 Introduction

The former NSW Agriculture invested about $100 million per year in research, extension and education activities making it the largest provider of research and development services within the New South Wales government sector[2]. The opportunity cost of these investments is the benefits to the people of New South Wales were they used in other areas such as health and education. Hence it is important that the now NSW Department of Primary Industries can demonstrate that it uses these resources in ways that enhance the welfare of the people of New South Wales.

There has been a long history within NSW Agriculture of evaluating the returns from investment in specific R&D projects. These evaluations were often used to support industry funding submissions and focused on the economic benefits from changes in farm productivity.

In 2003 the former NSW Agriculture began a more systematic process of evaluating the economic, social and environmental impacts of major programs of investment in research, extension and education. Five areas were selected for evaluation in 2003 and it is anticipated that each year another group of programs will be selected so that a significant proportion of the Department's portfolio will be evaluated on a regular basis.

This report presents the results of the first five of these evaluations conducted in 2003. The five areas of investment evaluated and the authors of these reports are:

- Net feed efficiency breeding research in beef cattle – Griffith, G.R., Davies, B.L., Alford, A.R., Herd, R.M., Parnell, P.F. and Hegarty, R.S.;
- An assessment of research and extension in annual weeds (*vulpia*) in pastures – Vere, D.T. and Jones, R.
- NSW Agriculture's wheat breeding program – Brennan, J.P., Martin, P.J. and Mullen, J.D.;
- An assessment of research and extension in conservation farming – Scott, F., and Farquharson, R.J.;
- NSW Agricultures' advisory programs in water use efficiency – Crean, J., Shaw, A., Singh, R.P. and Mullen, J.D.;

Detailed reports on each of these evaluations can be found in the Economics Research Report series available on the web at: http://www.agric.nsw.gov.au/reader/10550.

This evaluation process serves a number of purposes. The first is an external requirement for accountability in the way NSW Agriculture used the scientific resources in its care.

This evaluation process can also be used within the NSW Department of Primary Industries to assist in allocating resources to areas likely to have high payoffs and to assist in designing research and extension projects that have clearly defined objectives consistent with the role of a public institution like the NSW Department of Primary Industries. Working through this formal benefit cost framework gives those involved – economists, research and advisory

[2] This work was done prior to the formation of the NSW Department of Primary Industries (on July1, 2004) through an amalgamation of NSW Agriculture, NSW Fisheries, State Forests of NSW and the NSW Department of Mineral Resources.

officers and program managers, a greater appreciation of the paths by which, and the extent to which, research and extension activities are likely to have an impact at the farm level and hence lead to better projects. Part of this process is a greater understanding of other trends in the industry and of the extent to which 'the market' is failing to deliver outcomes sought by the industry or by the community.

In this suite of evaluations we have begun a process of more explicitly considering environmental and social impacts of agricultural activities. Advocates of this process argue that these environmental and social impacts provide a rationale for continued government funding of the NSW Department of Primary Industries' activities albeit with a different focus.

It is important to recognize that the measures of economic performance used in these evaluations, already capture some environmental and social impacts. Measures of farm or industry profit reflect the impact of changed environmental conditions on yields and input costs but not off-farm impacts. Similarly, the measures of profit change used in this suite of evaluations are really measures of changes in industry profit, not just farm profit, which are shared between not only farmers, but inputs suppliers, processors and consumers, some of whom live in rural communities. Social and environmental impacts are further discussed below.

We would have liked to have been able to value all economic, environmental and social impacts and relate these to the investments made but generally we were only successful in valuing some of these impacts because of:

- uncertainty about the technology for farm production both now and in the future;
- uncertainty about environmental and social impacts both now and in the future;
- uncertainty about the value of environmental and social resources both now and in the future;
- limited resources to undertake these evaluations.

Our approach has been to first describe qualitatively the economic, social and environmental impacts of the actual or proposed investment. We also describe the rationale for government investment from a market failure viewpoint which seeks to identify the characteristics of the investment resulting in farmers individually or collectively underinvesting in the areas under consideration. We examine the share of public and private funding in the investment and compare this to a qualitative assessment of whether the benefits from the investment flow largely to farmers or largely to the community. Note this assessment of the relative shares of benefits flowing to farmers and the community and the link to the source of funding is a highly subjective one, unlikely to be the subject of unanimous agreement.

We then attempt to quantify as many impacts as practicable to arrive at common measures of economic performance such as a benefit cost ratio. There are insights to be gained from persevering with an empirical benefit costs analysis even under uncertain scenarios, particularly with respect to understanding the relative importance of key parameters, such as the rate and extent of adoption of technology, the on-farm impacts, and the size of the investment and its time path.

However in assessing these alternative investments we must always bear in mind that some impacts, often the environmental and social impacts on the community, are not quantified and

hence judgments are necessarily based on a subjective weighting of quantified industry economic benefits against unquantified environmental and social impacts.
A key step is to identify not only the expected impact on an industry of the investment, the 'with technology' scenario, but just as importantly, how the industry would continue to develop without the investment by NSW Agriculture, the 'without technology' scenario. Rarely is the 'without technology' scenario a no-change scenario because there are usually other sources of similar technologies leading to ongoing productivity growth. The need to identify appropriate 'with' and 'without' scenarios applies equally strongly to environmental and social impacts as to economic impacts. In assessing the 'with' and 'without' technology scenarios, key outputs from research and extension activities and communication strategies used are described to give credence to claims about the contribution of NSW Agriculture and to assumptions about the rate and extent of adoption of the technology.

1.1 Common assumptions and methodology

No single guiding principle, such as focusing on projects expected to be successful, was used in selecting the five areas for evaluation. The choice was made by Program Managers and the economists in their Programs. In 2003 these evaluations were conducted against a severe time constraint which favoured choosing for evaluation, investment areas where the economists already had some industry knowledge. The WaterWise project was chosen because a choice has to be made in 2005 as to its future and there was a companion external review of the project being undertaken.

A conscious decision was made to work at an investment level larger than a single project. Research and extension investments are made at a project level but many small projects have similar objectives and hence our aim is to evaluate clusters of these projects. In this report the term project most often refers to a cluster of similar projects.

A concerted attempt has been made to use a common methodology and assumptions where appropriate in these evaluations. Year 2002 was used as the common baseline. In all evaluations there was a flow of benefits and costs over years before and after 2002. Generally costs and returns after 2002 were expressed in year 2002 terms and required no further adjustment to real terms. However nominal income and costs prior to 2002 were inflated by the GDP deflator to 2002 terms so that all income and costs were expressed in terms of the common purchasing power of 2002 dollars. To reflect the opportunity cost (or time preference) of being able to use these funds in 2002, all such net flows were either compounded forward or discounted back to 2002 at a real discount rate of four percent. A dollar earned in 2020 is worth much less than a dollar in the hand in 2002 and similarly a dollar in 1980 could have been invested to be worth much more than a dollar in 2002.

In all cases, the benefits have been extended out to the year 2020. This is an arbitrary cutoff point as in some cases, such as the project about net feed efficiency in beef cattle, the benefits extend much further into the future, whereas the benefits from an extension program into water use efficiency may cut out much sooner. The costs of the WaterWise program began in 1998/99 whereas the investment by NSW Agriculture in wheat breeding has extended over many decades and in this case the evaluation has focused on benefits from breeding activities begun in 1980. In all cases, the benefits and costs of investment activities began prior to 2002 but after 1980 have been recognized up to 2020. In some cases the costs of extending the technology in years up to 2020 have been projected forward and hence are projected rather than actual costs. Hence none of the evaluations are neatly characterized as *ex post* or *ex ante*

evaluations. They contain elements of both historic record and forward projection which raises a question as to how to interpret the results.

1.2 Interpretation of Results

In our view these five evaluations have focused on research and extension activities largely undertaken in the past by the former NSW Agriculture and hence despite important components of uncertain future benefits they can best be interpreted as estimates of the returns from investments by the former NSW Agriculture in research and extension over the past couple of decades.

A more interesting but risky question is what do these evaluations have to say about the rate of return on investments the NSW Department of Primary Industries might expect in the future. Traditionally estimated rates of return to investment in agricultural research have been high (Alston et al., 2000), perhaps unwarrantedly high. Some have argued that such high rates of productivity growth are unlikely to continue because the major technical advances have been made. The basis of such assertions are unclear and aren't supported empirically. Mullen (2002) has argued that if anything, there is weak evidence that the rate of productivity growth in broadacre agriculture in Australia has accelerated in recent decades.

Hence for a broadly defined area of investment such as wheat breeding, which has seen yields increase steadily for a century, there seems little reason why industry benefits from a similar program of investment should not earn a similar rate of return to that estimated here. However there is now a strong private breeding sector which changes the 'without' scenario such that the contribution of NSW Agriculture in the future, over and above that of these private sector firms may be much smaller than previously.

For investment areas focusing on highly specific problems, it is conceivable that once the problem is 'solved' further investment is wasteful. So for example investment in extension activities to promote a specific set of already existing water use technologies or a pasture management strategy for a particular set of weeds may earn high returns to the point where adoption rates are high but continued investment in these areas then becomes wasteful.

Moreover the future returns from the use of public funds in research and extension activities with a productivity or industry focus are now likely to be constrained by the existence of a much stronger capacity by industry to undertake these activities. In choosing future investments not only must the rate of return be considered but the appropriate balance between public and private funding. Where the benefits flow predominantly to industry, as in wheat breeding, then industry ought expect to largely fund these investments but perhaps government should expect to pay a large proportion of research into the greenhouse gas dimension of the net feed efficiency in cattle technology, for example.

More positively, there is little evidence, from these five evaluations and from past evaluations of the activities of NSW Agriculture to suggest that the Department was not successful in identifying areas where good science could be applied to production technologies in agriculture for significant gains in productivity. Presumably these skills still exist in the NSW Department of Primary Industries and are now being employed to encompass not only concerns about productivity but also the broader impacts of agriculture on the community and the role of government in addressing this range of concerns.

1.3 Social and Environmental Impacts

There still seems to be much to learn about how to properly consider environmental and social impacts in analyses of investments in research and extension activities. One of the difficulties is that economic, environmental and social impacts are not uniquely defined and hence the way of classifying impacts is not unique and the risk of double counting is high.

As noted above, in the approach used here, measures of industry economic performance reflect at least some of the 'on-farm' and industry environmental and social impacts of new technology. However social and environmental 'spillover' impacts on the community are not reflected in industry measures of economic performance.

Some important dimensions of social impacts are how the benefits of technology are shared between different types of producers and the contribution of new technology to the social capital of communities. In general we have not attempted in these evaluations to examine the distribution of total industry benefits from new technology between these different industry sectors. However we do qualitatively assess whether the new technology under evaluation is likely to have been neutral in its impact on 'big' and 'small' farmers.

In addition to the impact on rural communities through economic activity, the number of people living and working on farms and their skills or human capital are important to the strength of community service and cultural organizations, referred to collectively as social capital. The social capital of communities is likely to be related to their size which at least in the past has likely been linked with the prosperity of agriculture. Hence there is concern about the impact of new technology or changes in natural resource policy on the size of rural communities and their social capital.

In general the impact of technology in agriculture has seen a steady transfer of resources, particularly jobs, to other often non-rural sectors of the economy. This is the story to date of economic development in developed countries. Australian agriculture has a strong export orientation dependent on world prices and hence unless productivity growth in Australian agriculture from new technologies matches that in its competitors, it will become uncompetitive on world markets and the rate of transfer of resources out of Australian agriculture is likely to be faster than otherwise. The relative size of agriculture in the Australian economy is little different to that in other countries, and rates of productivity growth seem similar suggesting that the net effect may have been small. It is also worth pointing out that over the past decade the rate of productivity growth has exceeded the rate of decline in the terms of trade, hence reducing adjustment pressures.

Stayner has noted that there has been a 'decoupling' of agriculture and the economic activity of rural communities such that the prosperity of agriculture is less important to the prosperity of rural communities than formerly although the impact on communities is not uniform. Little is known quantitatively about these types of relationships between rural communities and the agricultural sector. It is unclear what 'indicators of social capital' we should be monitoring and what is the empirical relationship between a new farm technology and these 'indicators' (valuing environmental impacts faces similar problems). In these evaluations we have settled for a subjective judgment as to whether there were aspects of the technology that were likely to lead to greater community impacts than would be expected of agricultural technologies in general. Again it is important to identify the appropriate 'with' and 'without technology' scenario.

2 Net Feed Efficiency in Beef Cattle – G.R. Griffith, B.L. Davies, A.R. Alford, R.M. Herd, P.F. Parnell and R.S. Hegarty

Description of Net Feed Efficiency

Feeding cattle is a major cost of beef production. In southern Australia, beef cows and their progeny are generally run on improved pastures until they are either sold direct for slaughter or as store cattle for subsequent finishing on pasture, or in feedlots. The cost of developing and maintaining improved pasture ranges between $7.50 and $12.86 /DSE/year depending on area sown and stocking rate. In a typical enterprise targeting the domestic supermarket trade, the lower estimate means that 60% of the variable costs of production are related to feed cost. Supplementary feeding with hay, grain and silage is often necessary to fill feed gaps for cows on pasture and to ensure young cattle grow to specification. Such supplementation adds further to the cost of feeding cattle. Further, the cost of feed accounts for 70% of the variable cost of operating a feedlot.

Net feed efficiency (NFE) refers to the efficiency of feed utilisation assessed after accounting for the requirements for growth and maintenance of body tissue, and is calculated as residual feed intake. This is simply the difference between an animal's actual feed intake and its expected feed requirements for maintenance and a particular growth rate. Genetic selection for improved feed efficiency aims to reduce feed-related costs and thereby improve profitability.

NSW Agriculture commenced R,D&E in this area in the early 1990s, with a major project funded by the Meat Research Corporation. Since then, NFE has been part of the research program of the Cooperative Research Centre for the Cattle and Beef Industry (CRC I) and the Cooperative Research Centre for Cattle and Meat Quality (CRC II). Recently, research has commenced on the relationship between NFE cattle and their outputs of greenhouse gas (GHG), where the experimental work has focussed on evaluating breeding for NFE as a GHG abatement strategy.

This area of research began in NSW Agriculture and the Department remains a key player, recognised worldwide as a leader in the science of NFE.

Approach to evaluation

The evaluation was approached in two parts. First, an attempt was made to properly account for all of the resources employed in this R,D&E cluster.

The total value of inputs to this NFE R,D&E cluster of projects were estimated to be $20.6 million between 1991/92 and 2019/20. For NSW Agriculture expenditures, actual project payments were taken from MRC and CRC documentation. Estimates were made of the FTE staff of different categories involved in the NFE cluster of projects over the various periods of time they were in operation, and in some, expected maintenance R&D out to 2020. The 2002 costs for representative FTEs were calculated as salary plus on-costs of 23%. The total cost of these NSW Agriculture inputs was estimated as $13.9 million on a present value basis using a 4% real discount rate.

For external funding, actual project payments were taken from MRC/MLA and CRC documentation where appropriate. An estimate was also made of the contributions of Breed Society extension officers to this cluster. The total cost of these inputs from external sources was estimated as $6.7 million on a present value basis. Thus of the total value of inputs into this R,D&E area, NSW Agriculture contributed over two-thirds.

Second, an attempt was made to estimate the economic, environmental and social benefits of the potential adoption of the NFE technology in the Southern Australian beef industry. The economic benefits at the farm level were assessed by the use of a whole-farm linear program representing a typical mixed beef-sheep farm on the Northern Tablelands of New South Wales. Gross margin budgets were developed for the NFE cow enterprise and the cow enterprise it would be expected to replace and account was taken of the dynamics of the herds over time. The farming system was simulated under both possible enterprise combinations and the financial outcomes of the farming system were compared. In making these comparisons, a very conservative approach to modelling the uptake of the NFE genetics was followed to allow for any potential negative but unknown relationships between NFE and other traits. Models were also calculated to assess the impact of NFE cattle in a feedlot situation.

Economic, environmental and social effects

The outcomes of this R,D&E cluster can be grouped as economic, environmental and social. The main outcomes of this R,D&E cluster to date have been economic. Genetic variation in residual feed intake exists, the trait is moderately heritable (around 0.4), and where it has been formally measured, there does not seem to be any significant adverse implications for other traits of commercial importance. Thus breeders can select for NFE and growth and meat quality and not have to make any significant trade-offs. The scenario for the cattle industry without access to the NFE technology would be that productivity would improve based on past and easily forecast rates of genetic gain. The NFE technology is taken to provide an additional improvement above that already filtering through from past R,D&E.

This information has been taken up by the Australian stud cattle industry, and Estimated Breeding Values have been made available in some breed societies to assist commercial producers introduce NFE-superior genetics into their herds. The adoption process has commenced, although only at very modest levels to date.

An on-farm testing facility has been devised so that cattle breeders can measure and monitor their herd with respect to NFE. Unfortunately, such a facility is costly to purchase and there is a high opportunity cost in allocating breeding stock to intensive feeding trials. However, new research is examining a simple blood marker test as a way of differentiating between NFE efficient and inefficient cattle.

The economic benefits of the widespread adoption of this technology throughout the southern Australian cattle herd was estimated to be an improvement in the NPV per breeding cow per year over the base herd of $6.55, evaluated at a discount rate of 4%. This per cow benefit was multiplied by the number of breeding cows in the southern Australian beef herd, and then by the assumed adoption rate of the technology to generate an aggregate value of $128.6 million for the cow-calf component of the southern herd. The increase in the asset value of the southern herd over time as the NFE trait diffuses through the breeding herd has been included in these calculations. For the feedlot sector, it was estimated that the savings in feed costs in a

feedlot in southern Australia due to the introduction of NFE cattle would be $4.34 per breeding cow per year, or an aggregate value of $29.4 million. Adding these components together, the total estimated benefits from the adoption of the NFE technology were calculated to be $158.0 million over the period 2003-2020.

In addition, the NFE technology has some quite positive but potential environmental outcomes. If a cattle producer introduces genetics with superior NFE, then over time the herd will require less feed to maintain the same herd size and farm income. This may result in a lower stocking rate and may provide some environmental benefits to the farm in terms of better ground cover, greater water holding capability and less grazing pressure on preferred pasture species. More promising though is the potential reduction in GHG emissions from more feed efficient cattle. Selecting for NFE will reduce GHG.

Social outcomes from the R,D&E in this area of work are more difficult to identify. Because the technology has been developed in Australia, the beef industry will be less dependent on imported genetics. This may result in more vibrant breed societies and industry organisations.

Comparing the benefits to all recipients in southern Australia relative to the costs incurred by all R,D&E suppliers resulted in a Net Present Value (NPV) of $137.4 million, an Internal Rate of Return (IRR) of 13% and a Benefit Cost Ratio (BCR) of 7.7. Comparing the benefits to NSW producers relative to the costs incurred by NSW Agriculture resulted in an NPV of $54.8 million, an IRR of 9% and a BCR of 4.9.

Funders and beneficiaries

It was noted above that of the total value of inputs into this R,D&E area, NSW Agriculture has contributed over two-thirds. Although there may have been good reasons for the mostly public funding in the early years of the research, the current mix of funding seems to be too heavily weighted towards public funds. Those components of the NFE R,D&E cluster that generate essentially private benefits to the cattle industry and cattle producers should be increasingly funded by those groups. The GHG components of the work should however be mainly funded by the public sector as the majority of benefits will accrue to society at large.

3 Improved Management of the Annual Grass Weed *vulpia* in Temperate Pastures – D.T. Vere and R .E. Jones.

Description of vulpia problem

NSW Agriculture has a history of research investment in managing weed problems in the temperate pasture areas. One focus of that research has been on the development of improved management practices for the major annual grass weed *vulpia*. Recent surveys have found that weeds comprised up to 80% of pasture biomass in some temperate areas and that typical *vulpia* contents are between 30 and 40% of pasture biomass. Livestock producers perceive weeds to be the major symptom of pasture decline in this part of the state. Temperate pasture degradation is recognised as being a major contributor to the wider environmental problems of soil erosion, salinity and acidity.

This evaluation related to an industry funded project that ran between 1996-2002 (DAN158) that focussed on the *vulpia* problem in the New South Wales temperate pasture areas. The benefits of that research were measured as the difference in the economic returns from the project (the *with-research scenario*) and those that would have resulted if the project had not been initiated (the w*ithout-research scenario*). The latter recognises that there has been a past investment in *vulpia* research by NSW Agriculture and other organisations.

Approach to evaluation

Vulpia and other weeds impose costs on livestock producers and their industries, and economic benefits result from improved management that reduces weeds. The main task was to determine the extent to which the project was expected to reduce the *vulpia* problem. The baseline that typified the problem was set at 36% *vulpia* composition after recent weed survey results. Under strategies involving tactical grazing and fertiliser use, the *vulpia* content could be reduced to less than 15% and maintained there with good grazing management. This was the maximum benefit that could be achieved from the research. To recognise the uncertainty that is associated with the estimation of the benefits and their realisation by producers, minimum (25%), most likely (20%) and maximum (15%) benefit values were elicited from the project staff for the *with-research* scenario. The *without-research* scenario involved a maximum benefit of 20% *vulpia* biomass (from 36%), most likely of 25%, and a minimum of 35% biomass. The difference between the simulated benefits of both scenarios represented the benefits from *vulpia* research that can be attributed to the DAN158 project. Adoption values were also elicited and simulated as a probability distribution, with the most likely level of adoption being 35% of the wool industry on the tablelands for the with-research scenario, and 30% for the without-research scenario.

DAN158 was largely conducted under the auspices of the Weeds CRC. The total costs of *vulpia* research were determined as being $2.1 million which was the amount of DAN158 funding and the value of by NSW Agriculture's in-kind contributions to the Weeds CRC. An additional cost of $6.6 million was allowed for *vulpia* extension activities by NSW Agriculture over the 24-year period (1996 to 2020) of the benefit-cost analysis.

Economic, social and environmental effects

The results indicated high levels of economic benefits from the *vulpia* project. The annual net project benefit had a mean value of $58 million. The benefit-cost analysis generated a mean NPVof $196.9 million and a mean BCR of 22.2. These results demonstrate that research by NSW Agriculture into the improved management of *vulpia* has the potential to generate substantial long-term economic benefits. These benefits are equivalent to the value of the livestock production increases (in this case, wool) that result from reducing the *vulpia* and increasing the perennial grass content in a pasture. Other socio-economic aspects of the results showed that wool producers outside the New South Wales temperate areas lost economic surplus (from a mean -$21.7 million to -$47.8 million) because they were unable to adopt the cost-reducing technology and faced a reduced wool price. All wool consumers gained from *vulpia* research because of expanded wool production and lower wool prices. Improved *vulpia* management is also considered to produce important environmental benefits by encouraging a greater use of deep-rooted perennial grasses and the beneficial effects of these on mitigating soil problems and reducing water table discharges.

Funders and Beneficiaries

The financial costs of DAN158 were met by the International Wool Secretariat with in-kind contributions from NSW Agriculture. The wool industry has been the principal beneficiary of the *vulpia* research and has appropriately provided about one third of the funding. All sections of the state's community will benefit in the long term from the environmental improvements that will result from increasing the perennial content of temperate pastures. These benefits are mainly expressed through reduced soil erosion and salinity and the reduced discharge of salts into waterways. However it would seem that the focus of this research has been on productivity gains and hence it seems appropriate the share of industry funding be half or more in the future implying that industry support of future extension programs is required.

4 Wheat breeding – J.P. Brennan, P.J. Martin and J. D. Mullen

Description of the wheat breeding program

The Wagga wheat breeding program has been operating for over 100 years. In that time, it has released a flow of new wheat varieties for wheat growers in south-eastern Australia. In this analysis, the investment in that program from 1980 to 2003 has been evaluated. Given the lags inherent in wheat breeding investments, the benefits from those investments were estimated from 1993 to 2020.

The broad structure of the program has remained relatively stable for most of the period since 1980. The program consists of 2-3 wheat breeders, one breeder-pathologist, and a cereal chemist. The costs of the program have averaged approximately $1.4 million per year (in 2002 dollars) over the period. Over the period 1980-2003, NSW Agriculture contributed 59% of the total funds. In the period up to 1992, the contribution was 66%, but it has fallen since then and in the past 2 years, NSW Agriculture's contribution was 41% of total funds.

Approach to evaluation

The benefits of the program were measured as the difference in returns from improved wheat varieties in New South Wales over that period and the returns that would have been achieved in the absence of the Wagga breeding program. The assumption used to determine the impact without the program was that the rate of yield improvement in New South Wales would have been the same as for the rest of Australia if there were no Wagga program. For quality, the assumption was that without the Wagga program the rate of quality improvement in northern New South Wales would have been unchanged, but in southern New South Wales would have been 20% lower. Using these figures, the contribution of wheat breeding within New South Wales was to increase the value of wheat per hectare (incorporating both yield and quality) by approximately 0.5% per year in southern New South Wales and by approximately 0.15% per year in northern New South Wales.

Not all of those gains are attributable to the Wagga program. The contribution of NSW Agriculture to those gains was determined by the share of the Wagga program's varieties in the total area sown to wheat in NSW over the study period, which averages around 45% in southern regions and 12% in northern regions. Thus, the overall contribution of the Wagga program was to increase yields by approximately 0.25% per year in the south and 0.02% per year in the north. The benefits were projected into the future on the basis that the varieties released before 2003 will have a significant impact on production until 2013, when it will decline to zero by 2020.

Economic, environmental and social impacts

As a result of these calculations, the benefits from the program's investments from 1980 to 2003, averaging some $14 million in 2003, were well in excess of the costs of those investments. The BCR found in the analysis was 8.4. The NPV of the total resources used in the program over the period since 1980 was estimated at $321 million from an investment in present value terms of $43m.

The breeding program has social positive consequences, largely through its impacts on the incomes and prosperity of the farm sector. In addition, the development of marketing and processing industries around the increasingly specialised industry segments resulting directly from the changes that have occurred in wheat varieties also provides a social benefit of the breeding program. Wheat breeding does not favour large over small producers.

In environmental terms, the wheat breeding program itself is not likely to have major impacts, since the wheat industry would have been very similar whether or not there was a Wagga breeding program. However, to the extent that improved productivity from the Wagga program's varieties has allowed an expansion of the wheat industry, there could be some negative environmental consequences of the breeding program, such as those arising from the clearing of land, increased cultivation and increased use of herbicides. On the other hand, the high levels of disease resistance developed and maintained has meant that wheat production is not associated with large-scale fungicide use, and hence the danger of chemical contamination of the environment is less than it would have been without the resistance developed in this program. Some of these environmental impacts affect the costs and incomes of wheat farmers and hence are reflected in economic benefits and some spill over to the broader community and have not been valued here.

The costs of this program have been met partly by the New South Wales taxpayers through NSW Agriculture, and partly by the grains industry through levies from the Grains Research and Development Corporation (GRDC). The nature of the outputs of plant breeding programs is that there are large benefits that flow directly to industry, and a smaller level of benefits that flow to the community as a whole. These arrangements are reflected in the fact that the industry, though the GRDC and more recently through additional breeder royalties ("end-point royalties") levied on production, has increasingly funded the operations of the wheat breeding program. Recent institutional changes for the wheat breeding program have made it even more commercially-based for the future.

Funders and beneficiaries

Thus, while the program has produced considerable benefits, they have flowed mainly to the grains industry more generally and to the wheat industry specifically. Industry has increasingly provided funding for the program, and is likely to do so to a greater extent in the future.

5 Conservation Farming And Reduced Tillage In Northern NSW – F. Scott and R.J. Farquharson

Description of the Conservation Farming and Reduced Tillage program

The dryland cropping industries in northern New South Wales have developed over the past 30 years based predominantly on wheat production from fertile soils in a summer rainfall-dominant climate. Issues of crop performance and natural resource use, particularly soil erosion, initiated a number of programs of research, development and extension (RD&E) by NSW Agriculture, other public agencies, private firms and farmers themselves into improved methods of conservation farming and reduced tillage (CFRT).

Early in the CFRT investigative process it was realised that changing tillage for wheat production alone was insufficient to fully capture the potential benefits from such RD&E in a farming systems context. These programs have therefore included investigations into tillage, weeds, herbicides, crop diseases, soil water and soil nitrogen, grain legumes and farming system alternatives (including interactions between these various components), and the Department's advisory officers have extended the results to farmers.

Approach to evaluation

In the analysis reported here the investments by NSW Agriculture in those programs from the late 1970s to 2002 have been evaluated in an economic framework. An estimation of the increased profits from using CFRT practices, together with evidence of crop areas established with these methods, is the basis for the economic benefit analysis.

Two sets of results are presented in this report. The first is a comparison of industry benefits and public costs of these investments by New South Wales Agriculture up to 2002, and the second extends the project benefits and costs to 2020. Prior to 2002 the costs related to investments in both research and extension activities, whereas the costs to 2020 are projected to be for extension purposes only. In each case the with-program and without-program scenarios are specified and compared.

There are three main methods of crop establishment used in northern New South Wales – conventional cultivation, no till and reduced tillage. Conventional cultivation methods use mechanical means of weed control and seedbed preparation for sowing, whereas no till relies completely on herbicides for fallow weed control and uses adapted planters to sow into stubble. Minimum tillage methods incorporate one or two cultivations with herbicides for weed control. The without-program scenario was assumed to be represented by areas of conventional cultivation while the without-program was represented by the area of no till, and also by the areas of no till and reduced tillage crop establishment combined. Crop enterprise budgets and crop sequence budgets were established for each crop establishment method within each of seven sub-regions of northern NSW. These profit figures were used to estimate the difference between with-program and without-program net dollar benefits per ha, and aggregated, using survey data, to develop a total benefit estimate for comparison with RD&E costs.

Funding Sources

A considerable number of research projects and extension activities were undertaken for this cluster of projects. NSW Agriculture costs up to 2002 were estimated to have a present value of $25.6 million, and when extension activities were projected to 2020 the total was $28.3 million. Of the funds invested in research to 2002, 51% was in-kind (salaries, capital and other costs) and 49% was from industry. The main industry funding source was Grains Research and Development Corporation (GRDC) and its predecessors such as the Wheat Industry Council. The advisory activities were almost all in-kind contributions of NSW Agriculture District Agronomists who spent part of their time on this work. When extension/advisory services were included to 2002, the share of total costs was 39% funded by industry levies and 61% by state taxpayers via NSW Agriculture. When the extra extension costs to 2020 were accounted for, the share of investment was 32% industry and 68% NSW Agriculture.

In assessing the industry benefits from RD&E into CFRT, it is important to acknowledge the important work and influence of other agencies (State Departments of Agriculture and Natural Resources, the universities, CSIRO and farm consultants) and farmer groups in the whole process. Nevertheless New South Wales Agriculture has been a key source of farming systems research within northern New South Wales and a substantial provider of advisory/extension activities. Inspection and assessment of the share of papers and other publications presented at conferences and other forums was the basis for claiming 35% of the adoption of CFRT within northern New South Wales as being due to the efforts of New South Wales Agriculture officers and programs.

Economic, social and environmental effects

Based on these assumptions, the BCRs relating to NSW Agriculture efforts for no-till only and no-till plus reduced-tillage CFRT practices up to 2002 were 4.1:1 and 9.0:1, respectively. The NPVs of the benefits from these efforts up to 2002 were $78 and $205 million, respectively. When program activities were extended to 2020 the BCRs were 11.4:1 and 20.5:1 and the NPVs were $302 million and $568 million, respectively. These are very healthy returns on investment, with the projections to 2020 based on the assumption that extension activities will continue to encourage adoption. Unfortunately the nature of the benefit flow patterns prevented the calculation of associated internal rates of return.

There are likely to be other benefits from this RD&E program besides direct economic advantages in crop production and profit. These include environmental benefits from reduced soil erosion (and reduced remediation costs) plus reduced use of machinery and fuel. Using estimates of savings on erosion losses from other research, it is likely that up to 18 million tonnes of soil are saved annually from adoption of these technologies compared to conventional cultivation in northern New South Wales. Some of these savings are included in the on-farm profit estimates listed here, but other soil losses having off-farm effects have not been included. However, there may be some potential environmental detriments associated with persistence of herbicides in soil (and possible leaching into ground or surface water), a possible shift in the weed populations, and developing weed resistance to herbicides such as glyphosate.

The social consequences from maintained or improved farm profitability include maintenance of local communities, although other social and regional initiatives have also been

implemented for this purpose. Without the RD&E programs of NSW Agriculture and other agencies the slower growth in productivity is likely to have retarded farm and industry profitability, with concomitant effects on industry and community strength. It is impossible with the methods used here to quantify what would have occurred without the RD&E investments since other strategies or policies may have ensued, however the impacts of industry profitability are direct and important for farms, farm families and local communities.

Funders and Beneficiaries

The NSW Agriculture programs evaluated in this report have been partly funded by the GRDC or its predecessors. That funding is derived from industry levies and matching Commonwealth Government funds. The benefits measured here flow to farmers and industries but there are also positive impacts on consumers, transport services, processors, local towns and communities, and the environment. The use of industry and public funds to generate industry and public benefits is appropriate. While we have not been able to quantify benefits in both categories, it would not seem to be appropriate for further major RD&E expenditure in this area without industry funding. The results presented in this report show that the CFRT investments by New South Wales Agriculture in conjunction with other funders and providers have been an appropriate use of funds over the last 30 years.

Issues for New South Wales Agriculture

Some issues have emerged from this study for NSW Agriculture in its role of promoting and evaluating new technologies. While there has been a substantial increase in the areas of crop established using conservation farming methods (totals of between 15% and 40% for sub-regions in 2002), there is still a long way to go in encouraging the adoption of what is considered to be a profitable technology for many farmers. Further, the statistical information available on technology uptake from external sources (ABS and ABARE) was patchy, which meant that some bold assumptions were necessary about adoption trends over time. Future research could include a survey of farmers to find out more accurately the extent of adoption of the technology and constraints to the adoption of the technology.

6 Extension in Water Use Efficiency - J.Crean, A. Shaw, R.P Singh and J.D Mullen

This evaluation is an assessment of the economic, social and environmental impacts of the former NSW Agriculture's advisory programs in water use efficiency. Since 1998 the principal vehicle for this advisory work has been the WaterWise on the Farm (WWF) Initiative.

Description of WaterWise on the Farm

WWF is an initiative of the former NSW Agriculture's Water Management Subprogram and operates as an extension program as part of the NSW Water Reform Structural Adjustment Program (WRSAP). The WRSAP is an integrated package of extension, education and financial products and services designed to assist NSW irrigators to improve the efficiency of their use of irrigation water to offset the reduction in average long term irrigation extractions arising from the implementation of reforms in regulated and unregulated rivers and groundwater systems.

WWF is an extension program for informing and assisting NSW irrigators to improve the efficiency and effectiveness of irrigation water use, to minimise the negative environmental impacts of irrigation water use, and to improve the sustainability of the irrigated agriculture farm sector. Since 1999 the Water Management Subprogram has received budget enhancements of around $2.8 million annually to deliver WWF.

Through WWF, the Water Management sub-program has developed and delivered introductory vocational based training to just under 4,400 irrigators at June 30, 2003; conducted issue specific field and group events; developed, refined and implemented the statewide irrigation and drainage management planning framework; conducted communication campaigns through electronic and print media; and supported capacity building activities within the irrigation industry.

The core training provided by the WWF Initiative is the four day 'Introduction to Irrigation Management Course' (IIMC) which focuses on planning and implementing best practice irrigation and drainage management on farms. The course aims to promote the concept of Best Irrigation Management Practice (BIMP) and Technologies through "Right Amount - Right Time - Right Place" as an overarching guiding principle in using water. Technical staff also provide ongoing advice about efficient irrigation technologies to those who undertake the course and other irrigators.

Scope of this evaluation

The scope of this evaluation is confined to the extension activities of the Water Management Subprogram, most notably the WWF Initiative, related to greater efficiency in the on-farm use of irrigation water. The evaluation does not consider other aspects of WRSAP including the provision of financial services. In particular, the water reform process in NSW and Australia has an objective of improving river health by diverting some water from irrigated agriculture with significant economic, social and environmental benefits and costs. No attempt has been made here to consider the impact of the broader water reform process. Our objective has been to relate the economic, social and environmental benefits from the

adoption of water efficient technologies being promoted by WWF and the Water Management Subprogram to the investment by the NSW Government in WWF.

We have evaluated WWF as an extension program attempting to hasten the adoption of technologies and practices related to improving water use efficiency. The economic effects of the WWF initiative include water savings, product yield or quality improvements, and reductions in costs that may arise from the adoption of water management technologies recommended in WWF related activities. We have made some assessment of environmental and social impacts of these productivity gains but this is necessarily qualitative rather than quantitative.

Approach to evaluation

The WWF Initiative has attempted to reach irrigators in many industries across NSW. This was a deliberate choice to ensure that all industries affected, not just the large industries, had access to some assistance in adjusting to change occasioned by the Water Reform process. The promotion of different sets of technologies and best management practices across multiple industries and locations made a comprehensive evaluation of the program difficult. Given limited resources for this evaluation, we decided to focus on those regional/industry complexes where program management felt that WWF had been most effective, in the expectation that the benefits from these selected areas would more than cover the total costs of the Initiative. The complexes selected for evaluation included:

i) Lucerne industry in Central and Northern NSW;

ii) Cotton industry in Northern NSW

iii) Cherry industry around Orange and Young; and

iv) Viticulture industry in Southern NSW

To the extent that we have not attempted to assess the benefits of WWF in other catchments and industries, the evaluation represents a conservative estimate of the value of the Initiative. This evaluation required about 60 days of professional time and our judgment was that little would be served by extending the analysis to other complexes.

In each of the four evaluations, we have characterized the impact of the WWF Initiative as bringing forward the adoption of either new technology or best management practices by a certain number of years rather than influencing the maximum level of adoption. The Lucerne industry case study was the only exception, where the lack of industry structures suggested that WWF would actually increase the maximum level of adoption as well as influencing its rate.

A mixture of technologies and best management practices was evaluated across the case studies. In the case of lucerne and cotton, the WWF Initiative promoted better scheduling of irrigation applications involving more frequent but lower volumes of water which had the effect of reducing groundwater accessions and evaporation whilst reducing yield losses associated with both under and over watering. Better irrigation scheduling is principally a management change although normally some relatively minor infrastructure changes (reducing the length of runs, increasing the size of outlets etc) are also required. In the case of viticulture, the principal change promoted by WWF involved the conversion from furrow or spray based systems to drip irrigation systems. Changing to more efficient drip irrigation systems reduced crop water use and groundwater accessions whilst also providing yield and

quality gains. More efficient water use in the cherry industry involved increasing the number of drippers per tree to allow faster and more targeted irrigation reducing watertable accessions and increasing fruit size.

Economic, social and environmental effects

The economic benefits from WWF were estimated to be approximately $88.0 million (in 2002 dollars), exceeding estimated total expenditure on the Initiative from 1999 to 2005 of $19.8 million (also in 2002 dollars). Hence the net present value from this investment is estimated to be $68.2m, the benefit-cost ratio is 4.45 and the internal rate of return is 49 per cent. Investments by the Initiative in the lucerne and cotton industries generated the greatest benefits in absolute terms.

It should be noted that these economic benefits are shared by irrigators, agribusiness and consumers in the form of increased income and have important social consequences for regional communities. In addition, the skills developed by irrigation communities through the *Waterwise* initiative have added to regional social capital allowing more effective participation in the water reform process and greater capacity to adjust to reduced access to water. These potential benefits of increased social capital were not quantified in this report. The social impacts of the water reform process were considered to be outside the scope of this evaluation.

These estimates of economic impacts also reflect at least some of the on-farm environmental impacts of changes in water use efficiency. Changes in water use were valued at market prices. In addition technologies to improve water use efficiency can have positive environmental outcomes through reduced groundwater accessions and lower levels of irrigation salinity. These impacts were identified but not valued. Improved river health arising from the water reform process was attributed to the broader reform process and was not valued in this report.

Funders and Beneficiaries

The costs of WWF have been primarily met by the NSW Government with a minor contribution from the Australian Government through the Natural Heritage Trust (NHT). The NSW Government contribution has been through the Department's Consolidated Revenue Funds and through a budget enhancement. Irrigators incur opportunity costs in attending the training courses offered but these costs have not been valued in the financial analysis reported here.

Irrigators are clearly the principal beneficiaries of WWF. However, WWF was established to assist irrigators adjust to water reforms. Many of these impacts, primarily reduced access to irrigation water, were imposed early in the reform process whereas benefits accrue as improved practice is implemented. Governments have regularly intervened to assist adjustment processes particularly those arising from changes in government policy. Hence there are legitimate grounds for WWF to be publicly funded even though many of the benefits of increased water use efficiency are captured by irrigators. Funding for the Initiative is scheduled to cease in 2005. Were WWF to continue then industry might be expected to meet a share of the costs unless there are further changes in irrigators' entitlements to water.

7 Comparison of five evaluations

Summary statistics from these five evaluations are presented in Table 1. The size of investments by NSW Agriculture ranged from $14 million to $52 million in present value terms in 2002 (where the investment period was different for each project.) The NPV of the flow of benefits range from $16.5 million to $568 million . Hence BCRs range from 1.5:1 (water efficiency project) to 22:1 (*vulpia* in temperate pastures).

In each evaluation some assessment was made of environmental and social impacts although in a qualitative rather than quantitative manner at this stage. We note again that measures of economic performance often capture some environmental and social impacts. In general our judgment is that for most of these technologies the social impacts related to these particular technologies are likely to have been small. The exceptions are the *vulpia* projects, where temperate zone woolgrowers gain at the expense of other woolgrowers, and perhaps the WaterWise program.

The social impacts of the overall water reform process may be quite significant with those using water in a consumptive and associated industries losing out to those 'using' water for environmental purposes who may live in different communities. However the social impact of the Department's extension activities promoting water use efficiency are likely to be much less significant. An intensive educational program such as Waterwise may build up the problem solving skills of farmers in a way that benefits themselves and their community (social capital) in tackling other problems.

Some would argue that technologies that encourage the expansion of agriculture through increased profitability, almost tautologically threaten the environment by allowing agriculture to move into more marginal areas. However all investment areas considered above seemed to have some potential to offset the off-farm environmental impacts of agriculture and the scale of these impacts is likely to be larger than an expansion in the size of agriculture. The net feed efficiency research in beef cattle was originally focused on efficiency within the beef industry but recently it has been found that feed efficient cattle contribute less to greenhouse gas emissions and it seems probable that continued breeding research will lead to ways to effectively manipulate this 'attribute'. Some breeding advances in the wheat industry may lead to less pesticide use. More vigorous pastures are likely to lead to lower accessions to watertables and higher quality runoff. Reduced tillage farming arose from environmental concerns both on and off the farm, particularly with respect to soil erosion and soil structure but risks the development of herbicide resistance and greater use of chemicals.

One reason for at least qualitatively identifying these environmental and social impacts is that to the extent they occur off-farm, there arises a potential for government to participate in funding the research and extension activities from which they arose. For investment areas where the great majority of economic, environmental and social benefits flow to farmers, the rationale for government funding is weak. Where the flow of benefits to the community is significant then the role for government funding is stronger because without this funding, the industry is unlikely to invest in these technologies to the extent desired by the community.

In all five areas there are expected to be some benefits flowing to the broader community. However, because we have been unable to value the environmental and social off-farm impacts only a subjective judgment has been made as to whether the share of the total benefits to the community is high, medium or low. Conservation farming and the management of

vulpia have a range of environmental benefits some of which flow off-farm. Common benefits relate to water accessions and quality, and soil erosion. Additional benefits for conservation farming include reduced burning of stubble, and reduced use of fossil fuels, offset by a greater use of herbicides. Perhaps relative to the other investment areas, the share of benefits to the community from these projects is medium and hence perhaps it is appropriate that the government fund about half the investment in this area. At present the share of government funding is in the order of 60 –70%, although a proportion of this in both cases relates to future extension programs assumed to be funded by government. An approach to industry to help fund this extension given the potentially high rates of return to these projects seems appropriate.

For the other three areas the flow of benefits to the community seem in the low to medium range and hence industry should be providing more than half the funds invested in these areas. At present the share of industry funding ranges from 55% in wheat breeding to 30% in the NFE project in the cattle industry. Perhaps there is a stronger case for government support of the research activities within the net feed efficiency project dealing with greenhouse gas emissions but perhaps MLA would also expect to fund a proportion of these activities recognizing that half its funds come from the general community. The WaterWise program was a specific short term project funded by the government in compensation to farmers for the water reform process and hence the question at this time of the appropriate level of industry funding does not arise. This question would arise were there proposals to extend the term of the program.

The conservation farming and management of *vulpia* projects earned the highest rates of return. Such high rates of return may arise if the cost advantage of the technology is overstated, if scale of the industry to which the technology applies is overestimated or if the cost of extending the technology is understated. This issues were carefully considered in the course of the evaluation, hence the potential benefits from these technologies appear to be large. It would seem sensible for NSW Agriculture and the funders of these projects to carefully examine whether an adequate extension programs are in place to ensure that these large potential benefits are captured. It may be the case that the high rate of return is largely driven by the potential scale over which the technology is applicable and that the farm level benefits are moderate requiring a strong extension program to convince farmers of the benefits of the technology.

The WaterWise program appears to have been the least successful area of investment. There are obvious qualifications to this finding. We did not have to resources to try to estimate the impact of the program in all industries and catchments in New South Wales and we tried to quarantine the effect of the companion Land and Water Management Planning process going on in the irrigation districts of the state. In our view while extending our analysis to cover more industries and catchments will increase the estimated rate of return, it is unlikely that the returns to this project are as high as for the other investment areas because the scale of WaterWise impacts in these other areas has been small.

The WaterWise program was the only solely extension program in the group. We valued the program as the advance in the rate at which efficient water technologies were adopted. We would expect that while the farm level impact of an extension program is more immediate than that of a research program, the impact is also likely to be short lived as farmers gain knowledge about the new technology from other sources. Only in the case of lucerne did we recognize that the number of farmers adopting the technology may also be higher because

prior to WaterWise there seemed to be few other sources of information for lucerne growers. These considerations suggest ways in which extension programs can be targeted to earn higher rates of return.

Table 1: Summary of NSW Agriculture Evaluations, 2003

	Net Feed Efficiency in Cattle	Vulpia in temperate Pastures	Conservation farming in North	NSW Wheat Breeding	Extension in WUE technologies
Nature of Technology	Breeding to decrease feed intake	Increase perennial grass content of temperate pasture	Adopt reduced tillage in Northern farming zone	Breeding higher yield and quality wheat varieties	Faster adoption of WUE technologies
Industry size in NSW	5m breeding cows	wool 182kt/ 572kt	1.5m ha	3m ha, GVP $1.2 b	
Maximum Adoption			50% (in no-till in 2020)		
Net farm benefits	$10.90/cow/yr	13% lower wool costs	$38-$124/ha/yr	$9.69/ha	
Economic Outcomes:					
PV of Benefits	$68.7m		$597m	$364 m	$88m
PV of Costs	$13.9m	$8.7m (incl. $6.6m extension to 2020)	$29m	$43 m	$19.8m
NPV	$54.8m	$196.90	$568m	$321 m	$68.2m
BC Ratio	4.9	22.2	20.5	8.4	4.5
IRR	9%			16%	49%
Environmental Outcomes:	prospective greenhouse gas reductions	reduced accessions better water quality	Soil erosion and structure gains more herbicides	minor gains and losses	linked to water reform process
Social Outcomes:	few specific to technology	wool producers in NSW outside temperate zone lose	few specific to technology	few specific to technology	increase in social capital
NSW Ag share of funding:					
Present	70%	67% (to 2020)	68% (to 2020)	45%	100%
Prospective[1]	Lower except in greenhouse gas area	Lower	Lower	Lower	Unchanged but temporary

1. A subjective assessment based on an assumption that for most projects economic benefits exceed environmental and social impacts

8 Summary

The interpretation of these benefit cost assessments is not straightforward. While an attempt has been made to standardize the methods and assumptions used there are still unique features to each evaluation which mean that not all investment costs and productivity gains have been valued. Further, little progress has been made in quantifying social and environmental impacts.

Even if these qualifications were overlooked, the small sample of five evaluations limit any attempt to make general statements about priorities and resource allocation in the NSW Department of Primary Industries. The small sample means there is little information about the opportunity cost of these investments. As the process of evaluation continues over the next few years the bank of information about the impact of investments by the NSW Department of Primary Industries investments will increase and hence it will become more useful in priority setting and resource allocation processes. However this evaluation process will never be so comprehensive as to be the sole basis for resource allocation decisions.

With these qualifications in mind, it would seem that the former NSW Agriculture has earned an adequate to high rate of return from the five areas of investment evaluated in 2003. Many of the benefits from these investments have been captured by the industry rather than the community but in all cases there are likely to have been positive environmental impacts that have benefited the community. A judgment about how benefits are shared between industry and the community is subjective because we have been unable to quantity all benefits. Nevertheless in our view there is some divergence between the proportion of benefits and costs shared by industry and the community and hence the NSW Department of Primary Industries should be seeking a greater level of industry funding in all areas except for the water efficiency program which is presently funded by a Treasury enhancement. If industry chooses not to increase its level of research then the Department needs to confine its commitment to those components of investment areas where the flow of community benefits is expected to be high.

8.1 Lessons learnt from this first round of evaluations

A number of lessons were learnt from this first round of evaluations. Some lessons related to the process, and these will be discussed first, and some related to methodology.

This year's evaluation exercise probably cost more than a professional year in time, (40 – as many as 80 days of professional time for each evaluation) not an insignificant investment at a time of tight budgets. An obvious question is how would the success of this evaluation process be judged in say five years time. Perhaps from an accountability viewpoint, this could be regarded as an overhead cost expected of a public research institution in the same way that resources are used to prepare financial statements. It is not clear whether or how central agencies value these accountability measures. They should certainly be made aware of their cost.

However if the information provided by these evaluations proves useful in setting priorities and allocating resources, then NSW Agriculture will progressively develop a portfolio of investments which earns a higher rate of return to industry and the community than previously and which has a more appropriate balance of public and private funding. While this would

seem to be a reasonable objective for an evaluation process, it is not clear how success in meeting this objective can be measured nor, as a consequence, how many resources should be devoted to this purpose.

Economists (and others, see a recent special issue of the Aust. J. of Agric. Science) have argued that these evaluation processes build up skills in economists, and research and advisory staff in understanding the impact of their activities on industry and consequently lead to the development of research and extension projects delivering higher rates of return to industry and the community. Again it is unclear how this build up of human capital should be measured. Indirect measures include external recognition of the skills of the Department's staff and greater success in attracting industry support. Despite this difficulty in measuring outcomes, our view is that this is where the main payoff lies to the evaluation process the Department has just begun. The benefits may not be obvious for a few years.

Largely because of the time constraint we faced, some economic impacts were quantified but with respect to environmental and social impacts, little more was done than qualitatively identify them. In future greater efforts will be devoted to quantifying environmental impacts, such as accessions to watertables, at least in physical terms if not value terms. Nevertheless it will remain the case that any judgement about the relative size of economic benefits compared to social and environmental impacts will be subjective. Hence any judgement about the appropriate level of public funding is also subjective. Our view is that collectively those involved in research allocation in the Department will become more skilled in making these subjective judgements consistently.

The short time frame for the evaluation process has also made it difficult to involve other scientists and engage in peer review processes. Normally we would expect these evaluations to be spread out over a year (total time constant) allowing more dovetailing with existing work and a greater degree of peer review. Note that the peer review process is an important means by which NSW Agriculture 'learns' about the impact of its investments.

The timeliness and sophistication with which these evaluations were conducted depended crucially on the knowledge held by economists about the industries and technologies they were evaluating and their established links with the scientists engaged in these investment areas. This store of capital was particularly valuable in carefully defining the "with" and "without' technology scenarios. This is the point at which inflated rates of return and inappropriate government intervention can easily be generated, so it needs careful consideration, consistency and peer review processes. Each investment area had features that meant simple 'cookbook' approaches would have been misleading. Even with this level of knowledge each evaluation required at least 40 days of professional time. It would seem to be unwise at this time to begin evaluations in areas where economists have little involvement.

Not unexpectedly key parameters that influenced the returns from these investment were those capturing the rate and extent of adoption of technology. In all cases we had to rely on the educated guesses of research and extension staff as NSW Agriculture collects little information though time on these parameters. In developing research and extension investment proposals more effort should be devoted to first speculating about the impact of the proposed investment in terms of adoption parameters and second in measuring actual adoption parameters achieved.

From a methodology point of view, economists may make greater use of the simulation procedure used by Vere and Jones in their *vulpia* evaluation where they asked research and extension officers for a distribution of likely adoption outcomes and used these distributions in @ RISK to examine the sensitivity of the rate of return to these parameters. Perhaps research and extension staff are more comfortable specifying a range of likely adoption outcomes than a point estimate.

Similarly rates of return are sensitive to the estimated on-farm impact of the technology. In the evaluations completed, a wide range of techniques were used to estimate this on-farm impact. We need to further develop our skills in using enterprise and whole farm budgets and linear programming models to develop estimates of on-farm impacts.

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