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1 Improving animal production

1.1 Genetics

1.1.1 Case study: BREEDPLAN

Opportunity
Accelerating genetic improvement in the beef industry increases on-farm income.

Project
BREEDPLAN is the genetic evaluation system for the Australian beef industry. Breeders submit pedigree, performance and/or DNA records, and the BREEDPLAN analysis calculates Estimated Breeding Values (EBVs), which are an accurate guide to animals' genetic merit.

The BREEDPLAN system has continually evolved over the last 25 years, developing the capacity to handle more traits and use more robust statistical analyses. This allows more data to be analysed and to produce more accurate EBVs.

MLA invests in projects to support this development, and to extend BREEDPLAN to stud breeders and commercial producers. These projects are all aimed at contributing to faster genetic progress in Australian beef breeds.

Multi-Breed Data for Maternal Traits
This project, undertaken with Victorian Department of Primary Industry and the South Australian Research and Development Institute (SARDI), aimed to generate a dataset of breed performance for maternal traits, forming the platform for a multi-breed maternal genetic evaluation. The data has been collected and has been used in research to estimate breed averages for key maternal traits.

BREEDPLAN Field Support in Southern Australia
This project, undertaken with Agricultural Business Research Institute (ABRI), extended BREEDPLAN principles to the southern beef breeds, focusing on general awareness and usage. BREEDPLAN numbers grew slightly over the project period, and the weighted average rate of genetic improvement increased from approximately $1.00 per cow per year to approximately $1.70 per cow per year.

Cross Breeding Tips & Tools
This project, undertaken with the Animal Genetics and Breeding Unit (AGBU) and beef genetics consultants, produced and distributed extension material on the benefits and practicalities of crossbreeding systems.

Beef Genetics Toolkit CD
This project, undertaken with AGBU and beef genetics consultants, produced and distributed a comprehensive guide to beef genetics tools and information on a CD.

Genetic Evaluation for the Australian Beef Industry -Towards New Horizons
This project, undertaken with AGBU, aimed to maintain and improve the analytical capacity of BREEDPLAN software, including new traits, improved models for analysis, and research into how best to integrate DNA information into EBVs. New traits have been included in BREEDPLAN for several breeds. A new, more powerful version of BREEDPLAN has been delivered to ABRI for commercialisation. Methods have been

developed for integrating DNA test results into BREEDPLAN EBVs, with the first such EBVs delivered to industry for tenderness in Brahman cattle.

Outcomes

Objective industry benefits

These projects in combination, contributed to an increase in the weighted average rate of genetic progress in cattle evaluated through BREEDPLAN from approximately $1.00 per cow joined per year to approximately $1.70 per cow joined per year. Numbers of animals being evaluated through BREEDPLAN were maintained through the period.
The availability of more accurate EBVs allows breeders to make more accurate selection of the best animals. Producers have more confidence in the EBVs supplied on sale bulls.

Intangible benefits

Producers have greater confidence in using BREEDPLAN to make genetic progress and a better understanding of the choices that can steer breeding programs.

Triple bottom line

Economic

Genetic progress has accelerated, resulting in an annual increment of on-farm gross value of production (GVP) rising from around $6.7m to around $11m. This means that the benefits for producers are now growing an $11m extra in year one, $22m in year two, $33m in year three and so on, rather than $6.7m, $13.4m and $20.1m.

Social

Producers have improved confidence in use of the technology, including in making bull-buying decisions.

Environment

No benefits identified.

Future

Further work is anticipated in the multi-breed evaluation area, since the data collected in the project in this cluster, while valuable, has some statistical limitations in terms of how accurate between-breed comparisons for maternal traits will be.

Rate of genetic progress continues to increase, partly due to increasing skill and confidence in using BREEDPLAN and related technologies. The area of DNA markers – their use in selection and integration into breeding programs – is growing, and further work by AGBU will continue to ensure industry obtains best results from DNA technology.

In recent years, the focus of R&D investment has included development and use of genomic technologies, and a greater focus on effective breeding programs. There are clear signs that the rate of genetic progress is accelerating further.

1.1.2 Case study: Angus and Shorthorn breed progeny tests

Opportunity
Genetic improvement of the Australian Angus and Shorthorn cattle breeds can increase the profitability of around half of southern beef enterprises.

Project
Progeny testing programs were undertaken with Angus and Shorthorn cattle to identify high merit sires for wider use throughout each breed, collect data on traits that are otherwise not readily recorded and build datasets which allow calibration of DNA marker tools.

Integrated Angus Progeny Test Research Program
This project, undertaken with the Angus Australia breed society, aimed to progeny test approximately 36 Angus sires for a range of growth, carcase and eating quality traits. The progeny test was achieved successfully, with all data being included in BREEDPLAN evaluations for Angus cattle.

Shorthorn genetic improvement
This project, undertaken with the Shorthorn breed society, progeny tested approximately 100 Shorthorn sires (over a 10-year period) for a range of growth, carcase and eating quality, feed efficiency and fertility traits. All data is now included in BREEDPLAN evaluations for Shorthorn cattle.

Outcomes

Objective industry benefits
Greater use of elite (high EBV and $Index) young sires within both breeds has lead to reduced reliance on imported sires.
Genetic progress has been accelerated, especially in Shorthorn cattle, where the rate of progress is now double the rate prior to the project.

Other benefits
Both projects have provided data which has been used in calibration of DNA marker tests. Without this data, the Australian industry would have had no capacity for independent, objective evaluation of these tests.

Triple bottom line

Economic
Acceleration of genetic progress in Shorthorns increases profitabilty for commercial producers, and the increased use of elite young Australian sires reduces costs to the breeding sector.

Social
Both projects have improved breeders' skills and confidence in use of genetic technologies.

Environment
No identified benefits.

Future
Both breeds are continuing to invest in progeny testing programs.

1.1.3 Case study: DNA marker technologies for beef cattle

Opportunity
DNA marker technology has potential beef industry applications through developing DNA tests that will accurately assess animals' genetic merit for a particular trait or set of traits.

Project
MLA has undertaken strategic research in DNA marker technology in the areas of marbling, tenderness and polledness. MLA has also calibrated a range of DNA marker tests for several traits in Australian beef breeds in the SmartGene project.

Identification of the Genetics factors for Marbling
This project, undertaken with the Beef CRC and CSIRO, aimed to identify genes or genetic regions with significant impact on animals' ability to marble. Several gene regions have been identified, and are the basis of a test for ability to marble which is commercially available.

Evaluation of TEND3 Marker Tenderness in Cattle
This project, undertaken with the Beef CRC and CSIRO, sought to increase knowledge on the effects of a previously identified marker for tenderness in cattle. Estimates of the effects of the marker on shear force (tenderness) have now been obtained.

Genetic options for replacing dehorning of beef cattle in Australia
This project, undertaken with the Beef CRC and CSIRO, aimed to identify the gene(s) involved in control of polled/horn status in beef cattle, and if possible to develop a commercial test for the gene(s). A DNA marker for polledness has been identified, and is now in pre-commercialisation R&D, aimed at accurately understanding how best to use it in different breeds. There is more information on this project in Section 2 of this document.

SmartGene for Beef
This project, undertaken with the Beef CRC, CSIRO, Genetic Solutions, and ABRI, calibrated a range of DNA marker tests for several traits in Australian beef breeds. Results are now in the public domain.

Outcomes

Objective industry benefits
Each of these projects has identified genes or gene markers which are being used in industry herds. As yet, outcomes are limited. This is due to the short period of time the tests have been available, but each offers benefits for the traits targeted. The SmartGene project has been very important in estimating the effect due to a number of the genes for specific traits, allowing industry to make informed decisions on the value of the tests.

Other/intangible benefits
The SmartGene project has been very important in establishing the concept of independent evaluation of DNA tests and of putting the results into the public domain. In addition, it assisted in the work to integrate DNA information into EBVs.

This independent evaluation has helped establish some credibility standards and procedures for DNA tests, and these procedures will be used routinely in future to ensure an informed marketplace.

This has led to some greater caution around use of DNA tests, but stronger standards will ensure industry makes more appropriate investments at the individual enterprise level than would have occurred otherwise.

Triple bottom line

Economic
The economic benefits of the tests developed to date are still small. The benefit from avoiding inappropriate investment in DNA tests is considerable but hard to accurately estimate.

Social
The skills and confidence in use of this technology developed through this cluster of projects are proving valuable, with learnings also helping to shape further research and industry investment.

The ability to reliably breed for polledness offers very large potential animal welfare benefits.

Environment
No benefits identified.

Future
These projects represent the first wave of a growing body of research and industry investment in DNA technology. Further research will be undertaken about specific genes, tests based on thousands of pieces of DNA and how best to use DNA technology.

1.1.4 Case study: Predicting genetic conditions in cattle breeding

Opportunity
In several beef breeds, managing recessive genetic conditions is an ongoing concern, especially in situations where widespread use is made of individual sires. This is because all animals carry small numbers of unfavourable forms of genes, and if there is inbreeding (mating animals with ancestors in common) two copies of these unfavourable forms can come together, and cause significant problems. Genetic tests are now available to indicate the presence of unfavourable forms of genes in individual animals. These genetic tests for a number of unfavourable recessive conditions combined with the right computer software could deliver a pedigree tracking tool that can massively increase the ability of cattle breeders to manage undesirable genetic conditions.

Project

In 2009, MLA with Angus Australia, the Australian Brahman Breeders' Association, and ABRI, undertook a project to link breed society databases with software developed by Professor Brian Kinghorn, of the University of New England. A software tool was developed that can be used to predict the genetic makeup of every animal in a breed pedigree, when only a few key animals have actually been tested.

The software, named "GeneProb", is now routinely available for all the beef breeds operating in Australia. GeneProb also allows breed societies to predict the genetic makeup of all animals in a pedigree for favourable or unfavourable genes, where a test for the genes exists. For example, there is a tenderness marker in Brahman cattle, where four genes are known to have a significant effect on tenderness of the meat. A test is available for each of the four markers.

Outcomes

Objective industry benefits

GeneProb assists producers to manage genetic conditions and also ensures high genetic merit carrier animals stay in the breeding population.

GeneProb has been used extensively by Angus Australia to help their members manage three significant recessive conditions. Analysis is conducted frequently (often weekly), with every analysis involving all animals on the Angus Australia's database. This is almost 1.3 million cattle. Electronic reports for every genetic condition are made available through a secure download area to almost 900 Angus members each time an analysis is conducted.

Breeders and breed associations can also learn how to use genetic testing more cost-effectively, through better targeting of expensive DNA tests. In every population there are some key animals that reveal the most about the genetic makeup of the whole breed. Identifying the most informative animals for testing means less DNA testing is required.

Intangible benefits

Angus Australia has been able to change to a management policy, rather than aiming to eradicate certain genetic conditions. This is preferable, as eradication policies bring a risk of some producers choosing to not report genetic conditions.

Triple bottom line

Economic

Fewer calves will be lost to conditions resulting from genetic disorders, and breeders can pursue genetic progress while more effectively managing the risks of inbreeding.
Fewer cows are lost, as some genetic conditions affecting calves result in a higher incidence of calving difficulty and maternal mortality.

The use of GeneProb significantly reduced the number of animals needing testing by Angus Australia members. It is estimated that its use reduced the number of tests from as many as 150,000 to about 30,000 per genetic condition. This has saved the beef industry more than $12 million (120,000 tests x 3 conditions x $35 per test).

Social
Animal welfare is improved by producing fewer calves with genetic disorders. Further, losing calves (and cows) to genetic disorders is distressing for producers and potentially unfavourable for the broader industry.

Breeders develop more confidence in managing their way in the increasingly complex world of genetics.

Future
By the end of 2010 Angus Australia will be using GeneProb to manage five genetic conditions.

If GeneProb is used well, in conjunction with genetic testing, genetic recessives in cattle could be managed very effectively and are unlikely to ever become a significant problem in the Australian industry.

1.1.5 Case study: Sheep genetic improvement

Opportunity
Genetic improvement of the Australian sheep flock can increase the profitability of sheep enterprises.

Project
MLA supports various programs to underpin genetic improvement in sheep. Sheep Genetics, the Sheep Genomics Program and the Sheep CRC's Information Nucleus Flock are all funded by MLA and Australian Wool Innovation Limited (AWI) to provide infrastructure for the genetic improvement of sheep.

Sheep Genetics
Sheep Genetics is the genetics evaluation service for the Australian sheep industry, including both the wool and meat growing sectors. It is a partnership between MLA and Australian Wool Innovation Limited (AWI) started in 2005, building on MLA's previous LAMBPLAN and Merino Genetic Services. Combining both partners' knowledge on research and development, Sheep Genetics seeks to maximise the rate of genetic gain in Australian sheep. Sheep Genetics helps breeders and producers to make genetic selection decisions through delivery of breeding values in the form of ASBVs (Australian Sheep Breeding Values) database. Producers can use the information to develop breeding programs that suit their markets and production systems.

LAMBPLAN and MERINOSELECT are evaluation systems developed and managed by Sheep Genetics. Sheep Genetics also delivers results from the Sheep CRC's Information Nucleus flock to the sheep industry. The Information Nucleus data is used in incorporating DNA or genomic information into the routine genetic evaluations in LAMBPLAN and MERINOSELECT.

LAMBPLAN
LAMBPLAN predicts an individual sheep's ability to produce progeny to meet market requirements. LAMBPLAN focuses on the traits that affect profitability for prime lamb production (growth rate, carcase traits and reproduction). LAMBPLAN now produces

breeding values on around 2 million animals. Current estimates are that LAMBPLAN has directly influences more than 70% of the genetics of prime lamb production in Australia.

Merinoselect

Merinoselect provides breeders and producers of Merinos with ASBV information to improve their breeding programs. It is the Merino sector analog of LAMBPLAN, and covers wool quantity and quality traits as well as those for growth, carcase etc delivered through LAMBPLAN. MERINOSELECT is currently evaluation approximately 35% of the annual Merino ram intake of industry.

New traits

Sheep Genetics has focused on traits for growth rate, carcase and reproductions as they are key profit drivers for prime lamb production. Since 2007 birth weight, gestation length and lambing ease have also been added, along with additional wool and easy care traits especially relevant to Merinos. In 2011 Sheep Genetics is releasing breeding values for intramuscular fat in sheep as this trait is correlated to meat tenderness and is a desirable sheep trait.

Sheep Genomics

MLA's Sheep Genomics program conducted basic research in genomics – what genes influence traits and how those genes could be targeted in breeding programs. Gene markers (segments of DNA) can identify useful animal traits much more quickly than progeny testing. The Sheep Genomics project released a DNA marker chip for use in R&D and pre-commercial trialling in 2009. The DNA marker chip is being used in Sheep CRC research, which is evaluating how to best apply the technology in commercial sheep breeding.

Outcomes

Objective industry benefits

Sheep Genetics provides sheep producers with accurate genetic information on approximately 250,000 new animals each year, across all the commercially relevant breeds. Some 45% of sheep/lamb producers use ASBVs or index values in sire selection or purchase and an estimated 66% of the total lambs produced for slaughter were produced by terminal sires registered with LAMBPLAN. As a result of this selection, carcase weights of leaner lambs have increased and a higher percentage of lambs from reached the targeted market specifications.

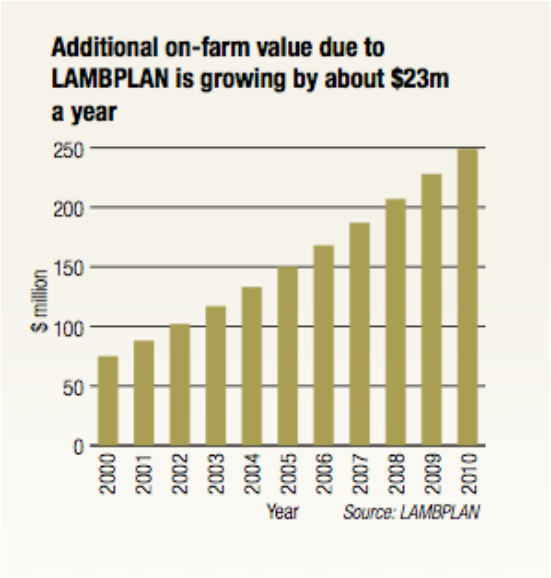
Intangible benefits

The information developed and delivered by Sheep Genetics significantly reduces production risk and uncertainty for commercial producers by allowing accurate genetic decisions to be made with confidence. This confidence, or reduction of uncertainty, has been costed, but is certainly appreciated by breeders and producers. Building on this, there is a much greater confidence that problems or opportunities can be overcome or grasped via genetics. This confidence flows through into industry's capacity to take on new products and markets.

Triple bottom line

Economic

The annual increment of on-farm wealth generated by genetic improvement in the sheep industry is now approximately $32million (that is, $32m in year 1, $64m in year 2, $96m in year 3 etc). This reflects more profitable production from a constant, or in fact, declining ewe base.



Social

There is a growing tendency for like-minded breeders to collaborate in trialling new technology and in cooperative breeding programs. This develops and strengthens innovation capacity, and enhances the ability of farmers to play an active gmailrole in the development and deployment of breeding technologies, including the newer genomic technologies. There is some evidence that this capacity is applied in areas other than genetics, as farmers feel more empowered.

Environment

Sheep Genetics is assisting in the breeding of animals that make more efficient use of resources. For example, lamb production is around 25% higher than 15 years ago, from a ewe base which is approximately 33% smaller. This translates directly into less use of water and feed. In addition, the increased profitability of lamb production makes finances available for environmental amelioration.

Future

Within the period 2010-2015 it is anticipated that the sheep industry will have cost-effectively embraced genomic technology. The potential benefits of this are estimated at an additional $1billion Net Present Value over 25 years, with much greater ability to target traits such as eating quality and nutritional content of meat. This transition will fully involve breeders in the process, ensuring empowerment and focus on practicality and cost-effectiveness.

1.2 Supply chain management

1.2.1 Case study: Sheep meat eating quality

Issue

Consumers' experience of eating sheepmeat affects demand for the product. The better and more consistent the eating quality of sheepmeat is, the greater the likelihood of increasing the size of the market. Research in 1998 showed consumers reported that lamb failed their expectations up to 30% of the time.

Project

The Sheepmeat Eating Quality (SMEQ) program was undertaken by MLA with strong endorsement by the Sheepmeat Council of Australia from 2000 to 2006. The program

defined and improved lamb, hogget and mutton eating quality by identifying factors that affected the consumer's eating experience. An improved consumer test system was crucial to this work. The program developed practices and processes that enabled producers, processors, retailers and foodservice operators to improve the consistency and quality of Australian sheepmeat.

The SMEQ program investigated extending the shelf life of sheepmeat through new processing techniques. The effects of ageing, electrical stimulation techniques and temperature on the colour stability of sheepmeat are now well understood. Work has also been done on the effect of grass and grain diets on colour stability, due to their vitamin E and selenium contents.

This program has also developed a technique for distinguishing mutton from lamb based on a fat sample which may be useful for guaranteeing quality of meat supply. The program has also examined the impact of various genetic and non-genetic factors on eating quality. The effect of muscling EBVs on sheepmeat eating quality is now understood and work on the role of intramuscular fat (IMF) and its interaction with carcase genetics (leaner, more muscular, larger sheep) has begun.

Research undertaken in the SMEQ program now underpins the Meat Standards Australia (MSA) sheepmeat program. MSA is a supply chain management system that sets out the agreed standards for each step of the chain to improve the eating quality of all sheepmeat categories (lamb, hogget and mutton).

Outcomes

Objective industry benefits

Producers, processors and suppliers are employing SMEQ specifications, practices and technologies. Major retailers, Woolworths and Coles, have adopted best practice processing methods and quality assurance protocols in their supply chains. Better quality sheepmeat is being delivered to consumers and it is now possible to guarantee lamb eating satisfaction more than 90 per cent of the time. By increasing the quality of the product, consumers are willing to either pay more for red meat or they are willing to buy more red meat.

Eating quality is also now a differentiator in key export markets

Intangible benefits

MLA's Eating Quality programs, of which SMEQ is a component, have generated substantial international interest, particularly from Ireland, Northern Ireland and New Zealand.

Triple bottom line

Economic

SMEQ has a combined net present value to industry of $151 million (calculated in 2005 dollars, over a 30-year period at a 5 per cent discount rate) and an industry benefit-cost ratio of 15:1. These calculations encompass the Meat Quality Science and Technology program that developed machinery to electrically stimulate sheep carcases to improve meat tenderness.

Social
There is a significant social benefit from the training and up-skilling of 14,000 workers in the processing industry. Consumers also experience social benefits from the improved eating quality of meat and from higher incomes flowing through from increased exports and production in the red meat industry.

Environment
There are no environmental benefits.

Future
Data to improve quality assurance procedures continues to be collected as well as new 'smart' stimulation systems and new technologies for measurement of optimal animal feeding. The SMEQ R&D program has also stimulated further research now underway within the Sheep CRC, with MLA support, into genetic and genomic methods for improving eating quality while maintaining or improving nutritional content simultaneous with improving carcase yield.

2 Animal health and welfare

2.1 Animal health

2.1.1 Case study: On-farm diagnosis of Haemonchus infections in ruminants.

Opportunity
Infection by the blood sucking nematode Haemonchus (Barber's Pole worm) causes severe anaemia and can result in death and serious stock losses in ruminants. It is a serious problem in regions with summer rainfall, on irrigated pastures and at times during wet autumns within a Mediterranean climate.

Laboratory analysis was required to diagnose the presence of Haemonchus which means an inconvenient time delay and a cost to the producer. This is a disincentive to close monitoring which is an important management tool at times of high risk.

A cheap on farm test (e.g. dipstick) would encourage regular monitoring, improve parasite control and reduce the overuse of anthelmintics, which is costly and leads to drench resistance.

Project
This project set out to validate the dipstick for monitoring Haemonchus infections, through intensive field study, on farm trials and tests on routine laboratory submissions.
The commercially available Bayer Hemastix® was used to establish specificity for Haemonchus by testing sheep infected with common internal parasites and Ovine Johne's Disease.

Sensitivity was clearly established for Haemonchus but specificity scores varied with type of feed intake and there was a cross-reactivity with the presence of liver fluke infection, which also causes blood loss. These two technical issues needed resolution before the dipstick could be commercialised.

The Haemonchus Dip Stick Test has been developed by the Sheep CRC, supported by MLA and AWI and has been commercially available through Merial since Spring 2009.

Outcomes

Objective industry benefits
For the first time the sheep industry has an off the shelf, fast, reliable, inexpensive and accurate early warning test to monitor Haemonchus worm burden.

The dipstick test detects the presence of the nematode before egg production begins. It can therefore be used to predict risk and therefore assist in management decisions such as moving stock or drenching. Frequency of use can also be determined according to the time of the year and the seasons.

Intangible benefits
More reliable information on which to base parasite control decisions means more rational use of chemicals, leading for instance, to a delay in the development of drench resistance.

Triple bottom line

Economic
Reduction of stock losses and drenching costs, improvements to flock health, animal growth and fertility means improved profitability for producers.

Social
Better (earlier and better targeted) worm control not only improves the livestock producer's profitability, but also improves animal welfare.

Environment
Targeted use of drenches increases the health and safety of the farm environment and decreases the risk of drenches finding their way into the soil and water courses.

Future
Although it is effective earlier in the infection process, like faecal worm egg counts (FWEC), this test uses a proxy measure for worm burden. The search continues for more accurate, affordable and convenient diagnostic methods.

2.1.2 Case study: Ovine Johne's disease

Issue
Ovine Johne's disease (OJD) is a chronic wasting disease of sheep caused by the bacteria *Mycobacterium avium subspecies paratuberculosis.* The bacteria damage the bowel wall, resulting in severe weight loss, emaciation and eventual death. The cost of OJD on an average sheep farm in Australia is approximately $13,700 dollars per year (OJD.031 Final Report). Along with the threat to animal welfare, OJD has possible public health implications.

Project

MLA has invested in research into OJD since 1998 as part of the National Ovine Johne's Disease Program. This program, evaluated an OJD vaccine that is now widely used, developed on-farm guidelines for the management of affected flocks and pastures, and examined the economic impact of the disease. In 2005 MLA conducted a 'harvest year' to collect and communicate the results of all Australian OJD research.

Since 2005, MLA has undertaken research to better understand the OJD organism and identify risk factors as well as improving diagnostic tests. While the vaccine, Gudair® reduces sheep mortality research has confirmed that it should not be the only method of preventing the spread of OJD.

Understanding the OJD organism

MLA undertook research with the University of Sydney to better understand the pathogenesis of OJD. Techniques in genomics and proteomics were applied to study the gene signals and protein effects, respectively. This was done for both the causative bacterium, and the sheep, in order to understand the interaction between the two. To enable research in the early stage of infection, a reliable method for experimentally inducing Johne's disease in sheep was developed, a world first.

Effectiveness of vaccine

A MLA-funded project measured the rate of shedding of OJD organisms in the faeces of two and three year-old sheep on 12 infected properties in the Central Tablelands of New South Wales, several years following the implementation of a control program using Gudair® vaccine. The project found that in addition to vaccination, management changes may be required in some flocks, such as reducing stocking rates, particularly in the lambing paddock and improving nutrition to weaner and ewes at lambing.

Identifying risk factors for infection

Further research has been conducted into the identification of risk factors for infection of sheep flocks with OJD. The combined effect of flock management and soil risk factors on the level of OJD expression in 92 infected flocks was examined. Both management and soil factors were found to play a role in OJD infection, with the organic matter content of soil having a strong association with OJD infection level in infected Australian flocks. Recommendations for on-farm control of OJD have been refined as a result.

New diagnostic test methods

MLA has invested in research into new diagnostic test methods. Sheep that have OJD detected early in life can be removed from a flock before spreading the disease. This project developed new diagnostic test methods and advanced immunological, molecular biological and proteomic technologies were developed and applied to sheep for the first time.

Outcomes

Objective industry benefits

Implementation of this approach, along with biosecurity practices will lead to reduced infection levels and related losses in infected flocks, with or without vaccination. Sheep producers have the information to assess the risk of ceasing vaccination in their flocks and the risk of purchasing vaccinated re-stocker sheep.

Other/intangible benefits
Australia has a greater capacity to deal with diseases such as Johne's disease.

Triple bottom line

Economic
Implementation of OJD management strategies and vaccination can substantially reduce the high economic losses associated with the disease.

Social
Better understanding and management of the disease reduces the negative social effects experienced by producers with sheep with OJD.

Environment
Native animals have been ruled out as carriers of OJD which has indirectly protected native animal populations. Improved grazing management strategies have resulted in reduced contamination of pastures.

Future
A major trial of the effectiveness of the vaccine Gudair is continuing, taking samples from third generation sheep to see if they are still shedding *Mycobacterium*.

2.1.3 Case study: New ways to control internal parasites in sheep

Issue
Drug resistance in the treatment of internal parasites causes significant production loss and death in livestock enterprises, especially sheep, both in Australia and overseas.
Control of the parasites largely relies on the use of anthelmintics, the agents that cause an animal to expel internal parasites. Resistance is now widespread to all registered drenches. Until as recently as three years ago, the development of new anthelmintics did not appear to be imminent. There is also increasing consumer pressure for non-chemical control of parasites and diseases which has led to a search for alternative means of control such as vaccines, breeding for worm resistance, pasture control, and developing 'natural products' as a source of new anthelmintics.

Project
MLA's Gastro-intestinal Nematode Target Identification Program (GINTIP) began in 2003, when there was wide-spread anthelmintic resistance and no sign of any effort by the pharmaceutical industry to search for new chemicals to control gastro-intestinal nematodes in sheep. Nematodes are non-segmented worms, some types of which are disease-causing parasites. GINTIP sought to facilitate the discovery and commercialisation of new anthelmintics and/or vaccines. There were nine projects in the program, all of which have been completed. The focus of most of the studies was on the gastrointestinal nematode Haemonchus contortus (Barber's Pole worm), which is of economic significance to the Australian sheep industry.

The program made substantial technological advances in identifying suitable drug targets, taking advantage of nematode and mammalian genome sequence information available in published databases. They had to be essential for nematode development or

survival, had to preferably be present in more than one worm species, not be present in mammals and be expressed in a part of the worm which could be reached by a drug or vaccine. Gene function data from the free-living nematode C. elegans and data from drug resistance in cancer research, provided a basic understanding of nematodes' natural defence against foreign chemicals. A number of major cellular enzymes were identified that are essential to the survival of the nematode Haemonchus contortus. Their identification provides a means to discover novel enzyme inhibitors, sourced either from natural products or new synthetic anthelmintics, for effective treatment of nematode infections in sheep and other livestock. An alternative approach might be to synthetically reproduce the nematode enzymes and use them as the antigen in a worm vaccine.

Outcomes

Objective Industry Benefits

These projects have provided a solid foundation for the potential identification of new and effective treatments of nematode infections in sheep and other livestock. The concept of target validation represents significant improvement in the approach to developing suitable commercial drugs in the future.

The research effort has had a major impact on the breadth of knowledge and development of the scientific skills required for the future biotechnology industry. The project has internationalised the research and increased the global visibility of MLA as an industry body.

Intangible Benefits

These projects increase scientific training and improve the career opportunities for Australian researchers in the biotechnology industry both here and overseas. As the program neared completion, the launch of two new sheep anthelmintics was announced. It can be argued that MLA's GINTIP alerted the pharmaceutical industry to the real need for new ways to overcome drench resistance and prompted their new drug development.

Triple bottom line

Economic

A new drench for sheep will assist producers in more effective control of one of the economically most important inhibitors of profitable meat production.

Social

Inability to effectively treat worm infestation is an enormous burden for sheep producers, which can, in some instances, force them to cease sheep production. An effective new drench will provide substantial relief in such cases, giving them the peace of mind of better sheep husbandry.

Environment

Effective internal parasite control is essential for more efficient utilisation of the feed base, producing more meat from less fodder.

Future

Much more basic research is required before this new knowledge can be used commercially. The chemical structure of the enzymes needs to be understood, to provide a clue to the composition of future drugs or vaccines. Chemicals that are synthesized for

this purpose, will have to undergo stringent testing, starting with laboratory experiments in bacteria to prove that they don't cause mutations (changes in the target host's genetic make-up), which could lead to cancer or birth defects. It remains to be seen if this research will be taken up by the pharmaceutical industry, or require further investment from producers.

2.1.4 Case Study: Parasite control in southern prime lamb production systems

Opportunity
Internal worm parasites cost the Australian sheep industry around $350-400 million a year in control measures and lost production. This is more than any other disease. The impact of parasites on sheep and lamb production is seen in reduced growth rates, failure to meet market specifications, delays in marketing and lower carcase weights.

Project
The first of its kind in Australia, this project undertaken by South Australian Research and Development Institute (SARDI) with support from MLA, benchmarked the magnitude of the losses to profitable production from parasites and poor land management practices. Fifteen on-farm experimental sites were established from 2004-2007 representing all key production systems (dryland, flood irrigation, pivot irrigation and cropping). Success of current worm management strategies on each farm was studied. Levels of worm burdens on pasture and in sheep, particularly Trichostrongylus (Black Scourworm) and Teladorsagia (Brown Stomachworm) were measured. Epidemiological data for all production systems was developed. Other investigations included drench resistance, larval survival in dung and destocking practices. A comprehensive literature research was undertaken.

The project delivered detailed information on worm management in all production systems studied. The findings are also applicable to a much wider range of prime lamb producers where significant worm control problems occur. It demonstrated that modest change, within a five-year window, can achieve significant savings to industry. A successful extension program has been initiated with promising results.

Outcomes

Objective industry benefits
The data from this project will be incorporated in the web-based WormBoss®, the Sheep CRC's parasite management tool for producers. An MLA Tip & Tool publication, specific to Integrated Parasite Management in this production system, has been commissioned. The extensive electronic literature database, first produced in 2007, has been made available as an interactive CD-ROM, which has been promoted on numerous occasions and at different venues (the latest being the XIIth International Congress of Parasitology in Melbourne).

Intangible benefits
The interactive CD-ROM literature database is available to researchers, veterinarians, producers, educationists and students. Rural re-sellers and producer study groups are now showing interest in the project.

Triple bottom line

Economic
In taking up the findings of the report, individual producers can remove a major threat to individual farm profitability. Not only will loss of production be reversed but associated costs of drenching and drench resistance will be reduced. Increased cash flow will follow as production targets and market specifications can be met.

Social
Better worm management has a social benefit to individual producers as increasing worm burdens in flocks, and the resulting decreased cash flow, is very stressful. The potential evening out of cash flow will have a trickle-down effect on strengthening rural communities. There will be increased security of food for consumers and exporters with a more reliable supply of product. Also, increased gross production from fat lamb enterprises will reduce the need for government funding for graziers in times of market downturn and drought. Further social benefit will accrue from both the reduced reliance on chemicals for parasite control and the improved welfare status of sheep with fewer parasites.

Environment
Better worm management will result in healthier pastures. Fewer drenching by-products will enter the eco-system.

Future
Information from the study may be used to develop worm workshops, design a producer guide and a cross-references update for WormBoss®, the Sheep CRC's collection of information about worm management for producers.

2.1.5 Case study: Detecting screw-worm flies

Issue
Endemic in Papua New Guinea, Indonesia, Malaysia and The Philippines, the Old World screw-worm fly (Chrysoma bezziana) does not occur in Australia. Constant vigilance is needed to keep this parasite out of the country as it threatens both animal and human health in northern Australia. The introduction of screw-worm fly could cost the Northern Australian beef industry more than $900 million per year, from stock losses, treatment and management costs. It is therefore necessary to continually develop and improve screening methods for the collection and identification of screw-worm fly.

Project
If screw-worm flies enter Australia, earlier detection will lessen their impact. This project developed an improved screw-worm fly trap system using an existing trap, the LuciTrap®, with newly developed attractant, Bezzilure-2. This trap attracts more screw-worm flies and less other flies than previous trapping systems. The traps are a convenient detection tool that can be strategically located in areas of high threat, including shipping ports.

Worms collected in the new traps can be tested for the presence of screw-worm fly using a new assay. The new test (the Taqman® real-time PCR assay) was developed that targets only the DNA present in screw-worm flies. It is sensitive and fast to do.

This project was funded by MLA and undertaken by the Queensland Department of Employment, Economic Development and Innovation (DEEDI).

Outcomes

Objective industry benefits
Use of the improved LuciTrap® and the Taqman® PCR Assay gives the Northern Australian livestock industry a better chance of detecting and thus minimising a screw-worm fly outbreak.

Intangible benefits
It may be possible to apply the screening technology used in the detection of screw-worm fly to other insect problems (e.g. fruit flies and fire ants).

Triple bottom line

Economic
The Australian beef industry is better positioned to avoid a $900 million a year pest problem.

The Taqman® assay uses less labour, has better sample turnaround time and is more cost efficient than former methods of screening.

Social
Screening trapped flies used to rely on trained entomologists. Improvements mean that local industry staff can be trained to use the instrument. Scientists in overseas countries where screw-worm fly is endemic have expressed interest in collaborating in further research.

Environment
The new trapping and screening instruments allow faster turnaround time thus allowing for quick containment and eradication if screw-worm fly is detected. Early detection and eradication of screw-worm fly not only benefits the livestock industry of Northern Australia but also the rest of the country including the human population because screw-worm fly attack all warm blooded animals.

Future
Collaboration with overseas scientists and the extension of the methodologies developed could see better screening for other troublesome species both in Australia and overseas.

2.2 Animal welfare

2.2.1 Case study: “Is it fit to load?” guide for transport of livestock

Issue
It is important that the condition of livestock is considered before they are loaded for live transport, particularly during times of drought. This improves animal health and welfare outcomes. These outcomes are important and essential for the live export market.

Producers and livestock transporters needed an easy to understand guide to help them decide the fitness for travel of their livestock.

Project
A pocket sized illustrated guide was developed to help transporters decide if an animal is fit for transport. It includes pre-transport and during-transport considerations for stock. It was a collaborative project between the RSPCA, WA Dept of Agriculture, WA Dept of Local Govt and Regional Development, Livestock Transporters Association, WA Farmers Federation and WA Pastoralists and Graziers Assoc, WA Meat Industry Authority and Elders.

As each state and territory had different codes of practice for animal welfare, industry and governments have developed a national standard to be underpinned by legislation.

Outcomes

Objective industry benefits
Launched in 2004, the “Is it Fit to Load” guide was reprinted in 2005. Enquiries from other states meant that MLA has now produced similar guides for other states.
Since the launch there have been better welfare outcomes for transported stock, particularly during drought.

Intangible benefits
A photography library was developed depicting livestock conditions, which will be a useful reference source for other projects.

2.2.2 Case study: Genetic markers for polled cattle

Issue
Dehorning cattle can be detrimental to animal welfare. It affects growth rates of animals, thus lowering productivity, and is time consuming and costly. Horned cattle cause damage to each other and the bulls are not fetching as much at market as polled animals. However, complete removal of the horned condition requires accurate identification of the genetic status of animals – animals that are carriers of the horn gene are essentially indistinguishable from genetically polled animals.

Accordingly, conventional breeding programs can take up to 30 years to produce a polled herd. A DNA test that tests the likelihood of an animal having progeny with horns could be used to breed cattle without horns in a timeframe of around eight years.
Polled is the term used for the absence of horns on cattle, sheep and goats. Scurs are small horn-like growths in the same locations as horns would grow.

Project
Researchers are looking for a genetic test that will identify which cattle to breed to produce a polled herd.

There is some uncertainty regarding the exact genetic control of polled/horn in Bos Indicus cattle, and so developing genetic markers is the first step to developing a DNA test for Bos Indicus derived breeds. (Bos indicus are a type of cattle that are better adapted to hot climates, including breeds such as Brahman). The accuracy and applicability of these DNA tests need to be determined so that they can be used by breeders to make all their cattle naturally polled.

This research is a collaboration between CSIRO, the CRC for Beef Genetic Technologies and MLA.

A DNA marker for polledness has been identified, and is now in pre-commercialisation R&D, aimed at accurately understanding how best to use it in different breeds.

Outcomes
The exact financial benefits of removal of the horned gene in cattle are very hard to estimate because they include potential future impacts on market acceptability.

2.3 Live Export

2.3.1 Case study: Humane restraining boxes for slaughter

Issue
Australia is a major supplier of livestock for South East Asia and the Middle East, where livestock slaughter techniques without adequate restraint, lead to increased animal stress, and often result in dark cutting meat and a reduction in shelf life. This has seen meat from Australian cattle discounted in the market. Also extensively raised Australian cattle can pose a danger to abattoir staff as they are much more difficult to handle than locally bred cattle that are used to daily human contact.

There are also animal welfare concerns when cattle restrained for ritual slaughter are not stunned prior to slaughter. This is a global issue, which in Australia has seen considerable community concern for the welfare of Australian cattle slaughtered in overseas markets.

Improving animal welfare during pre-slaughter and at slaughter has the potential to improve meat quality, enhance operator safety, improve efficiency of processing, open new markets for Australian livestock and reduce community concern regarding the live export industry.

Project
The livestock export industry and the Australian Government have supported stunning and restraining boxes in Australia's live export markets since 1991. In 2000, the industry identified improving the traditional pre-slaughter and slaughter handling of imported Australian cattle in Asia and the Middle East as a priority. MLA and LiveCorp undertook a project to improve animal welfare standards and processing efficiency in overseas abattoirs slaughtering Australian cattle.

Between 2000 and 2006, a prototype cattle restraining box, and later improved versions, were built and installed in Indonesia, Malaysia, Indonesia, and the Middle East. Further modifications and improvements were made to this box in 2008 to address design shortcomings that had been identified, and in early 2010 designs were finalised for the latest box which can be used with or without stunning.

Operators were educated about the direct benefits of low stress slaughter to meat quality and yields, and operator safety.

The Mark 1 boxes are totally mechanical in operation making them relatively easy to maintain. The most recent box (Mark 4) can be manufactured as either a manual or automated restraining box. The Mark 4 provides the following additional advantages:

- Cattle can be restrained for traditional slaughter or stunned prior to slaughter.
- The individual animal's blood can be collected for use or sale by the animal's owner.
- Blood can be kept separate from abattoir effluent for environmental reasons.
- The restrained animal is rotated onto its side rather than falling to the ground
- The slaughtered animal slides onto a wheeled cradle rather than the floor.
- Manufacture is readily achievable in most destination countries.

The use of the boxes improves animal welfare, processing efficiencies and operator safety in overseas abattoirs. Their use results in an improved level of meat quality and improves the acceptance of Australian cattle in traditional overseas abattoirs.

Development of the restraining boxes was funded by MLA, with subsidised installation of approximately 150 restraining boxes throughout South East Asia and the Middle East separately funded by LiveCorp and ML, and since 2006, by the Australian Government. In addition there is estimated to be more than 200 additional "copy" boxes that have been built by local operators based on the original design.

Outcomes

Objective industry benefits

This project contributes to both the sustainability and expansion of the live export trade. It also improves economic returns by improving slaughter efficiencies, increasing carcase yield and improving meat quality.

A 2006 review found 25 copies of the boxes in Indonesian abattoirs, a strong indicator of their success.

Currently there are 115 known Mark 1 restraining boxes in overseas markets. The latest Mark 4 design is being installed in four selected abattoirs in SE Asia and four in the Middle East.

Intangible benefits

This project assisted in the maintenance of good bilateral relations between the Australian Government and countries such as Indonesia, Malaysia, Saudi Arabia and Egypt.

Triple bottom line

Economic

Improvement in meat quality and storability reduces the likelihood of discounting of the Australian product in live export markets and assists expand the live export market. This also has a positive effect on the complementary market for Australian boxed beef and sheepmeat.

Social
Both the Mark 1 and 4 restraining boxes meet all the religious requirements for the ritual slaughter of animals (halal). All designs address domestic concerns for the welfare of Australian cattle slaughtered in overseas markets through meeting relevant international guidelines for the humane slaughter of animals (OIE World Organisation for Animal Health Terrestrial Animal Health Code [2007] Article 3.7.5.3).

Operators have increased safety during slaughter.

Environment
Allowing for the safe collection of blood and preventing blood from mixing with other abattoir effluvia addresses environmental concerns surrounding the high biological oxygen demand of blood as a waste product.

Future
The restraining boxes will be installed in markets across South East Asia and the Middle East.

The Australian livestock industry and Federal Government have committed to ensuring that over 90%of Australian cattle in Indonesia is slaughtered using a restraining box.
Continuing support is needed by the operators of abattoirs to ensure the boxes are correctly built, installed, maintained and operated.

2.3.2 Case study: Hot Stuff

Issue
The risk of heat stress to cattle and sheep transported on ships is high, particularly during the northern hemisphere summer. Mortality starts when the temperature exceeds 34°C, depending on the class of livestock.

Minimising mortality during voyages and ensuring acceptable standards of animal welfare are essential for maintaining Australia's live export trade. Over the period 2006 to 2009, the export value across all live export industries in Australia averaged $910.6 million each year, with 74%, or A$742 million of these earnings going directly to livestock producers'.

Project
Hot Stuff is a heat stress risk model that predicts the risk of heat stress mortality of livestock during a voyage and identifies strategies to minimise these risks. Since its introduction in 2003, this software has been refined to better identify the 10-15% of shipments that are high risk.

The model provides a heat stress risk assessment for all classes of livestock and is based on individual deck pen air turnover (PAT) and wet bulb temperature, and adjusted for animal characteristics (liveweight, body condition, coat type for sheep and acclimatisation zone).

The development of Hot Stuff was funded by MLA and LiveCorp's joint live export program.

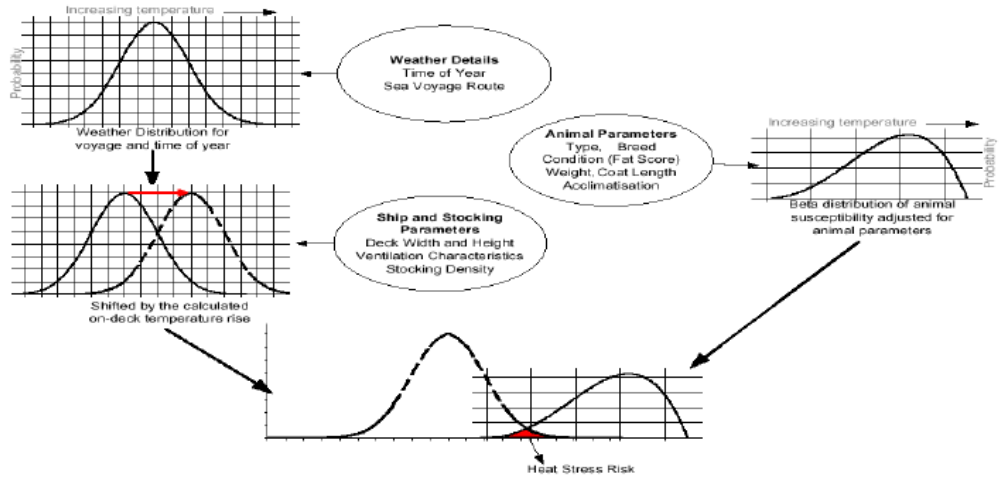


Figure 2-1: Summary of the Risk Estimate Methodology

Outcomes

Objective industry benefits

Hot Stuff is now used by all regulators as a risk management tool. All long haul voyages now use the model prior to a voyage and provide AQIS with the risk assessment.

Intangible benefits

Minimising livestock mortality during transport assists to ensure the long-term sustainability of the live export trade.

Triple bottom line

Economic

Any reduction in livestock mortality is economically beneficial, and moreso as the value of livestock increases.

Acceptable levels of animal welfare during voyages are essential for maintaining Australia's a year live export trade.

Social

Animals are less likely to suffer from heat stress during ship voyages and community concerns about animal welfare in live export are lessened.

Environment

No environmental benefits were identified.

Future

Version 4.0 of Hot Stuff is currently being developed to revise and improve the wet bulb temperature probability distribution for the sailing component of the voyage and to include additional voyage routes and ports into the software model.

A system is being developed to validate and monitor the performance of the model predictions against actual aggregated voyage data over time. This will enable further refinement of the Hot Stuff model.

2.3.3 Case study: Sheep mortality on ships

Issue
Minimising the numbers of sheep that die when exported by ship is essential to Australia's live export trade. Over the period 2006 to 2009, the export value across all live export industries in Australia averaged $910.6 million each year.

Overall mortality rates have steadily declined from around 4% in the 1970s to rates consistently lower than 1% since 2005. Understanding the causes and predisposing factors for shipboard mortality of sheep and lambs is needed to develop strategies to maintain and further improve mortality rates.

Project
Between 2005 and 2008 around 1.65 million sheep in 24 shipments were tracked from farm of origin to port of discharge. The most common cause of mortality was found to be Salmonella induced enteritis (34.4%), followed by inanition (23.9%) and enteritis/inanition (18.2%). Risk factors for mortality were age, ship and time of year.

Lines of sheep from some locations had a higher mortality rate on voyages. Seventy-four percent of mortality was traced to 18% of lines. This suggests that the immunity of sheep from some locations is compromised by property of origin factors or by the process involved in getting these animals to the assembly depot.

These strategies will reduce shipboard mortality:

- minimising salmonella challenge at the assembly depots
- promoting consistent industry adoption of the road transport guidelines
- avoiding sourcing sheep from high risk locations pending clarification and correction of the risk posed to these sheep,
- implementing a uniform information management system across industry to track sheep performance from origin to discharge
- improving the training and definition of responsibilities for shipboard veterinarians and stockmen.

This project was undertaken jointly, by MLA and Live Corp.

Outcomes

Direct industry benefits
Implementation of the recommendations is likely to reduce mortality in the live sheep trade for sheep exported from Australia. Controlling salmonellosis and inanition could reduce overall mortality to as little as 0.2%.

Triple bottom line

Economic
Prevention of sheep losses during export increases profitability for stakeholders. Increasing the proportion of sheep delivered in peak health protects Australia's reputation as a supplier of high quality livestock, contributing to the sustainability of Australia's live export industry.

The sustainability of the live export trade protects a gross value of production in the sheep and lamb sector of $220 million per year (Hassall 2006).

Social
The welfare of exported sheep is improved and the industry's reputation with the Australian community is protected.

Environmental
No environmental benefits were identified.

Future
Best practice strategies for the treatment of sheep suffering from salmonellosis and inanition are being developed. Several strategies to reduce inanition at feedlots are being assessed. The feasibility of developing salmonella vaccine for sheep is also being investigated.

2.4 Feedlot

2.4.1 Case study: Heat stress for cattle in feedlots

Issue
In the past, there have been a few instances where cattle have died at Australian feedlots have died as a result of heat stress. In addition to animal welfare considerations, the deaths are costly and result in community criticism of the industry.

Project
This project developed a Risk Analysis Program (RAP) to assess the likely heat stress to cattle in feedlots in various sites across Australia, using meteorological data. This software can assist operators to determine whether potential sites are suitable for establishment of feedlots and ameliorative measures that can be implemented to offset the risk of heat stress at existing facilities.

Feedlot operators found the first version of the RAP to be useful and asked that the RAP include more locations. The latest version has a total of 48 sites.

Data was analysed to investigate the effects of climate change in selecting a suitable dataset to adequately represent the potential future risk. The susceptibility of various breeds of cattle to high heat load has also been investigated. The updated version of the RAP has been modified to incorporate new research into the effects of heat on different breeds of cattle and updates of the meteorological database. It is also now available on the web.

More climatic information, as well as more biological information, means operators can now identify pens.

Outcomes

Objective industry benefits
Reduced deaths of cattle in feedlots due to heat stress.

Intangible benefits
The industry as a whole is better educated about heat load in livestock. As part of their compliance requirements with the National Feedlot Accreditation Scheme, the industry Quality Assurance program, all accredited feedlots are required to review and update their risk assessments (using the RAP) prior to the start of summer each year. This ensures the risk assessments address any changes that may have occurred in the breed and class of cattle being fed and keeps heat load management 'top of mind' leading into the summer.

Triple bottom line

Economic
Fewer deaths as a result of heat stress within feedlots reduce operator losses.

Social
Conditions for cattle in feedlots are improved, resulting in better animal welfare and reduction in community concern.

Environment
The information collected improves understanding of the impact of increased climate variability.

Future
More research and data about climate change and animal behaviour in feedlots will add to the usefulness of the RAP. It may be possible to adapt some of the results already produced for use by dairy and lamb producers.

3 Improving the environment, pasture and feedbase

3.1 Environment

3.1.1 Case study: Life cycle assessment of beef and sheepmeat production

Opportunity
Improving the environmental credentials of the livestock industry will have both business and reputation benefits for all producers. The agricultural industry is often cited as the second largest source of greenhouse gas emissions in Australia. Conducting a life cycle assessment provides accurate data on the amount of water and energy used to produce a kilogram of beef or sheepmeat, and estimates the greenhouse gas emissions (but not any sequestration) associated with that production.

Project
MLA conducted an environmental life cycle assessment of red meat production in Australia. The project investigated three supply chains: sheepmeat in Western Australia; premium export beef supply chain in southern NSW and an organic beef producer in Victoria.

Unlike some previous studies of this type that are bounded by the farming processes (ie, from the cradle to the farm gate), this assessment included processing facilities.

The global warming potential of the three supply chains ranged from 6.8 to 12kg of carbon dioxide equivalents (CO2e) per kilogram of Hot Standard Carcass Weight (or HSCW, an industry unit of measurement for meat). The highest contribution came from the organic beef supply chain, at 12kg CO2e per kg/HSCW. Feedlot beef produced 9.9kg of CO2e per kg/HSCW. Sheepmeat was the lowest at 7-8kg per kg/HSCW.

Energy use varied between 24 and 30 Megajoules per kg HSCW, primarily from the meat processing facilities. Water use (excluding rain) ranged from 18 to 540 L/kg HSCW.

Different steps in the supply chain processes contribute separately to the overall picture. In all three supply chains studied, the main source of greenhouse gas emissions was the animals themselves. Enteric methane, a relatively strong greenhouse gas, at both grazing and feedlot properties accounts for most of the burden.

In feedlots greenhouse gas emissions associated with red meat production were found to be increased on a per head basis, but the total emissions are lower when considered on a per kilogram HSCW basis. This is despite the additional energy requirements and associated greenhouse emissions related to the production and transportation of grain and other feeds to the feedlot.

The Victorian farmer purchased a considerable amount of soil improving additives, such as lime and basalt, which contributed as a one-off factor to greenhouse gases.

The energy demands of the meat processing facilities (the final step in the supply chain) dominate this section of the life cycle, primarily due to large refrigeration equipment. Interestingly, the transport effort of getting the animals to the processing facilities is small, at less than 2% of the total energy used.

Manure collected at meat processing works accounts for half of the solid waste generated in the meat life cycle. Waste generated on grazing properties is not rigorously reported and manure can be recycled into the land. Other waste generated on livestock properties includes tyres, chemical containers and old equipment.

This project increases the quality of information available to policy makers and others who want to know the answers to questions like: “What is the carbon footprint of red meat?”, “How much energy is used in making red meat?” and “Is much waste produced?”

Although life cycle assessment methodologies can vary significantly, this study found that the carbon footprint of redmeat production in Australia was equal or better than those of other countries.

Outcomes

Objective industry benefits

Accurate information is now available about carbon emissions from a small sample of beef and sheepmeat production enterprises that can be used to help industry negotiate a position as Australia’s climate change policies emerge.

Concerns about the effect on the environment of the increased proportion of lot feeding in Australian beef production can be addressed, as this production system was found to

generate lower total greenhouse gas emissions per kilogram of meat production than grass-fed production.

If consumers begin to make product selection choices on the basis of environmental considerations, information that contributes to a positive 'green image' will become a competitive advantage.

Triple bottom line

Economic
Life cycle analysis identifies the relative contribution of different production processes on using resources such as energy or water and therefore identifies the priorities for business decisions or future research to reduce costs and achieve efficiencies. The data generated has been used to represent an industry position on carbon labelling of food products in an ISO working group, and to counter misinformation from anti-meat groups with factual information from actual farm systems.

Social
The study has allowed MLA to present more objective information to consumers, and to challenge the misinformation associated with reporting virtual water use based on total rainfall calculations.

Environment
The results have been used to direct R&D funding to address the major impacts of resource use on the environment.

Future
MLA is implementing a strategy to highlight carbon reductions already achieved by industry, and investigating how further reductions can be achieved. Life cycle assessments are currently underway for several other meat production systems.

As more countries introduce eco-labelling for their food (ie, carbon footprint labels similar to existing nutrition labels), proof of a product's sustainability credentials will be important.

There is a chance that, with future research, cattle grazing pastures may be found to be carbon sequestration sinks with a positive effect on the environment. This aspect of meat production is not considered in current Life Cycle Assessment (LCA) methodology

Research into using dietary additives to reduce methane emissions was recommended in the (LCA) and is currently under research.

3.1.2 Case study: Great Barrier Reef – the Burdekin catchment

Issue
Grazing operations in the northern savannas of the Burdekin catchment of north Queensland experience distinctive wet and dry seasons as well as marked inter-annual rainfall variability. With an area of 130,000km^2, the Burdekin catchment is the second largest catchment emptying into the Great Barrier Reef lagoon, making nutrient and sediment management by all industries a priority. Each year during the wet season in the Burdekin catchment, an estimated 90 million tonnes of sediment is shifted, with around

2.4 million tonnes reaching the Great Barrier Reef lagoon. This can potentially affect the health of the Great Barrier Reef, and graziers lose productive soil, water and infrastructure, affecting the profitability and sustainability of those businesses.

Projects

MLA has been conducting research, development and extension into understanding the relationship between grazing management, land condition, run-off and erosion. In collaboration with our research partners, Queensland Department of Employment, Economic Development and Innovation (DEEDI) and CSIRO, projects at Wambiana Station and Virginia Park Station in the Burdekin catchment have been undertaken.

Virginia Park Station

In 2009 we reported on the results of an 8-year study that evaluated the impact of grazing land best management practices on Virginia Park Station in the Burdekin catchment. The practices of full wet season spelling and forage budgeting were examined for their impact on land condition recovery, landscape health and the consequent run-off of water, sediment and nutrients both from the hillslope and the catchment. Despite a sustained drought during the period of the study, these management practices led to an improvement in land condition through both improved pasture composition and cover levels in the monitored paddocks. These land condition changes were associated with reduced runoff from early wet season rainfall events and reduced hillslope sediment yield at two of the three study sites. However, at the site where there was a scalded area towards the flume there was no reduction in sediment yield. Monitoring of land condition and hydrological function at Virginia Park is ongoing.

Wambiana

Guidelines for sustainable grazing management were tested in the paddock at Wambiana, a working cattle station near Charters Towers, Queensland. Starting in 1997, the project evaluated a number of stocking rate and grazing strategies: moderate stocking, heavy stocking, variable stocking, rotational wet season spelling and SOI-variable stocking.

After 11 years the trial has shown that the least profitable and sustainable grazing strategy was the heavy stocking strategy. In comparison the moderate stocking, at or around the long-term carrying capacity (equivalent to average annual pasture utilisation of 25%), had an extra accumulated cash surplus of about $10,000 per 100 ha with less production variability/risk and higher levels of groundcover, better infiltration rates and reduced runoff of water, sediment and nutrients.

Outcomes

Objective industry benefits

The Virginia Park work has demonstrated that good grazing land management can improve land condition and has quantified the benefits to both runoff and erosion at both the hillslope and small catchment scale.

The Wambiana trial has demonstrated the production, financial and environmental benefits of moderate stocking relative to heavy stocking.

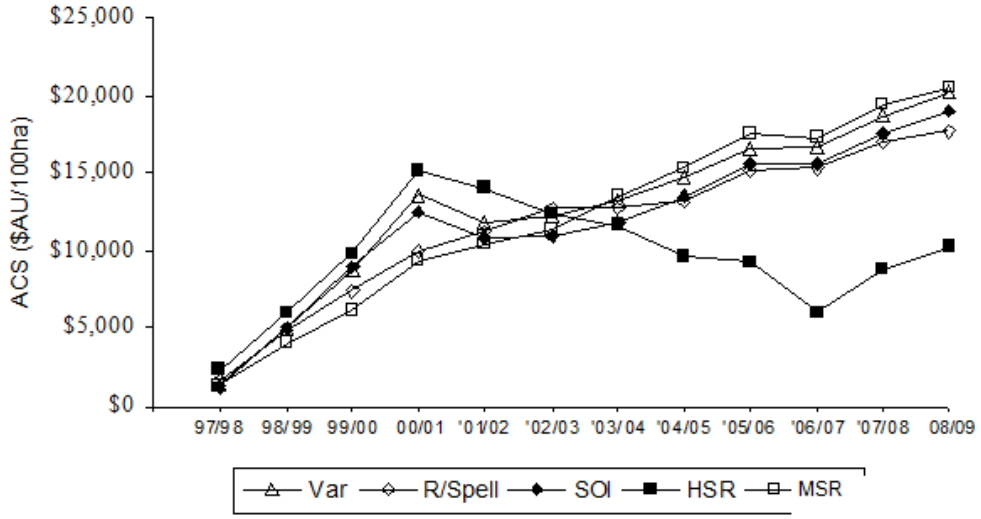
Intangible benefits

These projects show stakeholders in the Great Barrier Reef region that MLA and the northern beef industry are serious about quantifying the impacts of grazing on land condition, runoff and erosion, and in making recommendations to reduce our off-site impacts.

Triple bottom line

Economic

The Wambiana grazing trial has shown that a moderate stocking rate can be more economically successful than a heavy stocking rate (accumulated cash surplus after 11 years of $19,333/100 ha versus $8,850/100 ha). For a 20,000 ha property the difference in economic performance between moderate and heavy stocking equates to an extra $1.6 million of income over 11 years.



Accumulated cash surplus (ACS) for 5 grazing strategies from 1997/98 to 2008/09 (Variable stocking, Rotational spelling, SOI-variable stocking, heavy stocking, and Moderate stocking).

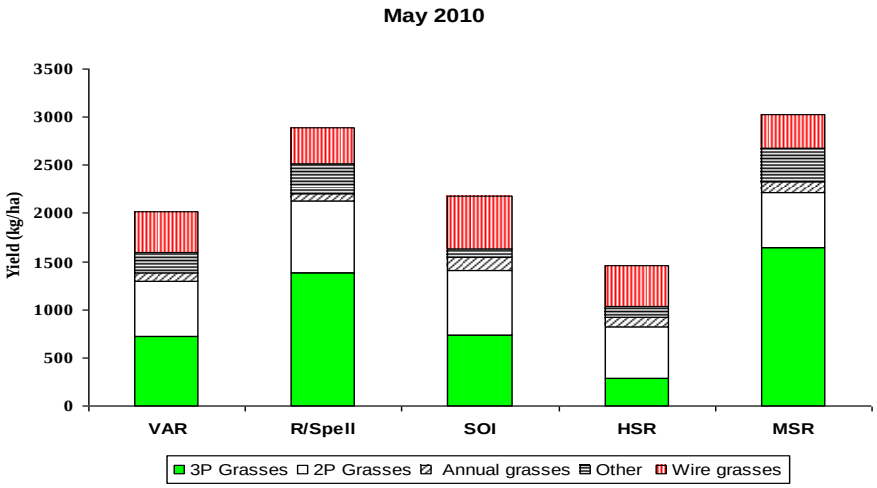
Social

Producers in the region are more confident that management practices are available that will help ensure sustainable beef production in the Burdekin catchment area.

Environment

The Virginia Park Station work has shown how it is possible to improve land condition and reduce hillslope sediment yield. As importantly, it has also identified issues that need longer term research (eg, soil infiltration capacity) and factors that may distort the relationship between land condition/cover and erosion (eg, presence of scalds at critical points in the landscape).

The Wambiana trial has shown how it is possible to be more profitable and also have land in better condition in terms of ground cover, land condition (ABCD framework), biomass, species composition, runoff and erosion.



Contribution (kg/ha) of different species groups to pasture yield in May 2010 across five stocking strategies at Wambiana. Data meaned over both replicates.

Future

Both the Virginia Park and Wambiana work are ongoing. At Virginia Park work will continue to monitor the long-term changes in land condition, runoff and erosion.

At Wambiana, following a detailed technical review of the results and a study site visit with local producers and DEEDI and CSIRO researchers in 2009, a revised experimental design has been developed which addresses two key gaps in our grazing management knowledge:

- how to realise the potential of varying stocking rate over time for sustaining higher average stocking rates
- the capacity of rotational wet season spelling to sustain higher overall stocking rates, either with set-stocking or with variable stocking management

3.1.3 Case study: Feral pig bait

Issue

Feral pigs affect Australia's agricultural industries by competing with livestock for pasture, trampling crops, fouling water sources, causing infrastructure damage and soil erosion, preying on newborn lambs and spreading endemic diseases to stock and humans. Feral pigs would potentially play a major role in the spread of any major exotic disease outbreak. Environmental degradation and the predation on the eggs of wildlife is also a threat.

Past control methods were costly and time consuming. The most practical, cost effective control was achieved through integrated baiting campaigns. Two of the toxins commonly used (warfarin and phosphorus) have already been withdrawn and the poison 1080 is now under strict control and its continued use and availability uncertain. Target specifity and animal welfare are a large concern as widely different methods of preparing 1080 baits in grain, diced meat and carcasses are used and large doses of toxin are required to achieve results.

Project

The PIGOUT® project, begun in 2004, was a collaborative project between the Invasive Animals CRC and Animal Control Technologies Australia, in partnership with state and

territory government feral pig management agencies. MLA and NFACP provided significant support. The aim was to develop and register a shelf-stable, manufactured 1080 pig bait that improved the efficacy and environmental safety of current pig baiting procedures. The bait had to be highly attractive and palatable to feral pigs, be target specific, cheap, easy to use and readily available to land managers.

A grain-based bait was developed that smells fishy, is highly coloured and appeals to omnivores. Each bait contains a 1080 toxin in its patented core, designed to minimise migration of poison, surrounded by a matrix which effectively contains nil or very little poison. The size and hardness of the bait is also designed to match the bite force of the feral pig.

In trials PIGOUT® provided a 78% reduction in pig numbers through ground baiting and 62% through aerial baiting. In all trials target specifity was very high. It was registered in December 2007.

Outcomes

Objective industry benefits

PIGOUT® has provided the agricultural industries with the first registered shelf-stable feral pig bait.

PIGOUT® has provided a convenient and safe way for producers to control feral pigs on their properties to reduce environmental degradation and stock predation, and improve production. PIGOUT® will also be a crucial control technique in the event of an exotic disease outbreak which would have the potential to threaten human health and Australian grazing industries.

Intangible benefits

The availability of PIGOUT® will be a positive incentive to maintain and continue agricultural enterprises, particularly sheep enterprises, which are close to feral pig populations, and are consequently difficult to manage.

Triple bottom line

Economic

The economic impact of feral pig activity on the agricultural sector is estimated to be $100 million annually. The production of PIGOUT® provides greater cost efficiencies in controlling feral pigs. It is more efficient than the labour intensive preparation, distribution and retrieval practices of baiting alternatives. PIGOUT® therefore encourages wider use by industry, so reducing the economic impact of feral pigs on the agricultural sector.

Social

Significant stresses on farming communities occur where feral pigs are in numbers, including concerns about human health as transmission of endemic diseases is possible. The availability and ease of use of PIGOUT® will help allay such concern.

Environment

The long-term environmental costs of feral pig populations are reduced. Damage caused to landscape, water courses, wetlands and predation on eggs and small wildlife by feral pigs, as well as the spread of fungus, is well documented.

Future
Research is underway to extend the use of the PIGOUT® for delivery of disease vaccines and contraceptives in pest species. Parallel to this study a new quick acting toxicant was discovered which can be delivered in similar patented core baits. This new bait, to be known a HOG-GONE, is based on sodium nitrite and is currently being tested.

3.2 Pasture and feedbase management

3.2.1 Case study: Grain & Graze

Opportunity
Australia's medium rainfall wheat-sheep zone accounts for more that 25% of all farms in Australia, 25% of total grain production, 30% of sheep and wool production and 10% of beef sales. Producers in this zone have been confronted with a number of threats to profitability and viability. These include declining terms of trade, and a range of land and water resource degradation issues such as dry land salinity, soil acidification, soil structural decline, erosion, loss of nutrients and surface water sedimentation. Within these prevailing climatic, market and resource conditions, opportunities existed to improve farm profit, sustainability and environmental health within local catchment contexts.

Project
Grain & Graze was a research and delivery program that worked with producers, researchers and catchment groups in the wheat-sheep zone of southern Australia to improve on-farm profitability, productivity and environmental health through a holistic approach to whole-farm vegetation management. A joint initiative between MLA, Grains Research and Development Corporation, Australian Wool Innovation Limited, and Land & Water Australia, this five year project (June 2003 – July 2008) sought to regionally identify the mix or combination of crops, pastures, livestock and vegetation that will deliver both production and natural resource benefits. The program goal was that by 2008, 6,800 producers would have adopted practices to improve both profit and natural resource management (NRM) outcomes. The project considered land use, management actions and geographical features (including soil type, rainfall and topography) in supporting production systems that improve farm profit while also achieving local catchment management targets.

Grain & Graze combined bottom-up regional processes, complex interdisciplinary systems research, national triple bottom line targets and novel methods of extension methodology in order to broaden the options available to farmers. This enabled producers to continuously adapt to the most optimal crop-livestock-pasture mix within the prevailing conditions.

Specific goals for the program included providing mixed farming enterprises with new, 'whole farm' knowledge, tools and capacity to adopt management changes that would lead to a 10% increase in profitability of livestock, crop, and pasture systems while maintaining, or enhancing, biodiversity and the catchment resources that sustain them.

The Grain & Graze program accelerated the adoption of other programs' outputs by three years, over that which would have occurred without the program. Without the Grain & Graze program, 40% of target producers (2,720 of 6,800 producers) would adopt the

outputs over 10 years, from 2008-2018. By contrast, with the Grain & Graze program, 40% of target producers would adopt the outputs over 10 years, from 2005 – 2015.

By its conclusion, around 39,000 Australian farmers were aware of the project, including over 18,000 mixed farmers who were the primary audience. Of these, more than 8,000 participated and around 4,000 trialled practices intended to provide benefits in terms of productivity, profitability, and farm and catchment environmental health.

Evaluation surveys suggest that 3,090 additional farmers are already prepared to adopt at least one new practice once market and climatic circumstances permit. Around 2,400 producers attributed practice change solely to participation in Grain & Graze, and based on the benefit cost estimates (6,800 producers made change by 2015), the result by 2008 was an outstanding success.

Outcomes

Objective industry benefits

During the five year period of the program, by adoption of Grain & Graze recommended practices, profit could be increased for mixed enterprise producers by 9% (against a target of 10%).

By August 2008:

- 39,000 farmers were aware of Grain & Graze activities
- 8,000 farmers had participated
- more than 5,000 producers were actively trialling activities
- 3,200 had made change.

Intangible benefits

The focus on achieving the dual goal of production and natural resource benefits brought together quite diverse groups with different strategic objectives. This has allowed more efficient expenditure of funds and greater understanding of the complexities of mixed farming systems in the minds of researchers, catchment management authorities and industry groups.

Grain & Graze comprised over 60 funding partners. These partnerships have enabled cooperation and interaction between research agencies, catchment management bodies, grower grows and RDCs. The Grain & Graze network and partnerships enables funding to be used effectively at a regional level, through national program efficiencies. The partnerships provide future opportunities for investment by national programs such as Caring for our Country. This is validated by Caring for our Country investment of $6m in the mixed farming systems program that has followed Grain & Graze.

Triple bottom line

Economic

The opportunity for increased profit from adoption of Grain & Graze technologies varied across regions, from 2% in the Avon to 19% in the Murrumbidgee. Assuming that the benefits last for at least a 10 year period from the start of the Program in 2003, the net present value assessment made in 2008 is estimated to be $14.8 million. This indicates that every dollar spent on the program has seen a return of $1.48.

Regional benefits were reported, including 66% of the growers surveyed in the Maranoa Ballone area thought Grain & Graze had been useful and would certainly help their profitability in the long term with a 72% increase (or 101,667 ha) in pasture rotations planned over the next five years.

In Corangamite there was a 130% increase in area of grazed cereal from 2004 to 129,000 hectares.

In Border Rivers there is 19,500 hectares of pastures planted on poor crop lands, attributable to Grain & Graze

Social

Confidence in management of complex mixed farming systems was shown to have increased for approximately 3,800 producers involved in the program.

A survey of Eyre peninsula producers reported that the program had substantially developed their pride and confidence in mixed farming.

In the Maranoa Ballone area 72% of land managers believed Grain & Graze had changed their attitudes and knowledge, and 70% believed Grain & Graze had helped them improve their strategic decisions.

Environment

Significant benefits to the environment are accrued from nearly all of the practices advocated by Grain & Graze. In particular, the top three key farm practices adopted suggest that it is likely water and soil quality have improved together with the condition and diversity of plants and wildlife on many mixed farms. The Biodiversity in Grain & Graze project alone covered farms aggregating over 172,000 hectares.

Regional change has been reported with grazing of cereals and stubble grazing in the Corangamite catchment. Grazing cereals reduces stubble loads, and can reduce the need for burning stubbles and the ensuing air pollution.

Participating catchment management organisations have recorded a reduction in soil erosion and dust-storm events in most Grain & Graze regions despite the occurrence of significant drought conditions where such degradation events are most common.

Future

Key themes from Grain & Graze have developed into a new mixed farming systems program. These themes of complex decision making, adaptive management, transitions between crops and pasture, growing and utilisation of biomass, are tied to delivering profitable outcomes for mixed farmers while improving water use efficiency, increasing ground cover and reducing soil erosion.

Six million dollars in funding was secured from the Federal Government's "Caring from our Country" initiative to support GRDC's new mixed farming system program achieve its change on farm goal.

3.2.2 Case study: Evergraze - More Livestock from Perennials

Issue
Losing desirable plant species reduces pasture quality. This is an issue for improved and non-improved (native) pasture systems in Australia. Around 60% of Australia's high rainfall zone is based on 'native' pasture, and 16% is classed as improved. Some grazing practices have decreased the proportion of perennial grasses in pasture in Australia's high rainfall zone. Practices that retain and increase perennials assist livestock production and can help reduce salinity, prevent wind and water erosion, increase biodiversity and improve soil health.

Project
'EverGraze – More livestock from perennials' was a joint program of MLA, AWI and the Future Farm Industries CRC. EverGraze investigated perennial-based grazing systems to reduce groundwater recharge and regionally important natural resource issues. Evergraze increased productivity for producers in the high rainfall zone.

A whole farm system of pastures, animals and management, EverGraze applies a common high-performance lamb production system and uses perennials strategically to achieve high weaning percentages and therefore improve profitability. The project has developed and tested new farming systems in different environments to ensure relevance across the whole of the high rainfall zone of southern Australia. Through modelling, EverGraze estimated catchment-scale impacts of the widespread adoption of future farming systems. With six 'Proof' sites in three states, EverGraze is developing and testing new farming systems in different environments. A large network of 'supporting' sites allows groups of livestock producers to try new perennial pasture systems or management practices such as hedge rows for lamb survival, perennials to increase ovulation rates, Lucerne to increase summer-autumn pasture production and grazing management of native-based systems.

EverGraze aimed for increases of up to 50%in profitability of a dual-purpose sheep enterprise while concurrently addressing a regionally relevant natural resource issue..

Outcomes

Objective industry benefits
EverGraze has devised farming systems that can significantly increase profit. Benchmarked against the "top 20%" of monitor programs, EverGraze production exceeded these benchmarks by 20%. The Hamilton Proof Site has shown the potential to double productivity over the district averages by matching species to the landscape and livestock production system to feed supply. The production systems improve water use by adopting EverGraze principles and so improve productivity for sheepmeat and beef producers in the high rainfall zone of southern Australia.

More than 13,500 people participated in EverGraze activities. It is estimated that 3,100 producers will have adopted one or more principles and practices by June 2011 as a direct result of being involved in the EverGraze project. EverGraze participants have changed management on 180,000 ha of pasture. This does not allow for change to livestock management. Producers involved in EverGraze activities are significantly more likely to have increased the area of perennials on their farms and are actively planning or

considering making changes to management and use of perennials in future years. They are also much more likely to be planning to make changes to livestock management in future years and be addressing environmental issues on their farms. Further, producers who have attended EverGraze field days and events have a better understanding (than non-participants) of matching perennials to soils, using summer active perennials, managing grazing to maintain 70% ground cover and managing grazing to improve persistence of perennial species.

Intangible benefits

EverGraze increased the capacity of rural based institutions to work together including regional natural resource organisations, producer groups and government agencies. The EverGraze network of more than sixty sites provided a node for delivery of information to producers around grazing systems, and on-selling of related MLA products and programs. The emphasis and advice on perennials and their management provided by next users, has increased.

Triple bottom line

Economic

EverGraze farming systems have provided evidence that in the high rainfall zone profit and natural resource outcomes can be achieved at the same time. Increases in profitability have been substantial when farming systems based on native pastures change enterprises from wool lamb production. The Hamilton Proof Site has shown the potential to double productivity over the district averages by matching species to the landscape and livestock production system to feed supply. In 2008 the Net Present Value of EverGraze was estimated to be $75.59 million (at a discount rate 5% over 25 years).

Social

Participatory research activities enable producers to gain skills, knowledge and confidence in management of perennials. Also, the leadership capacity of producers is increased through roles on the National Advisory Committee and the EverGraze Regional Committees. EverGraze also increased the capacity of rural based institutions to work together.

Environment

A weight of evidence has been produced indicating producers adopting perennial based systems will reduce recharge contributions to dryland salinity.

Future

MLA has a commitment to the Future Farm Industries CRC until 2014. A new RD&E program from 2011-2014, based on spatial arrangement of perennial vegetation to improved profit and natural resource outcomes, is under development.

3.2.3 Case study: Lucerne breeding program

Opportunity

Lucerne is a legume crop grown to increase livestock production that has a broad seasonal growth pattern across summer and winter. It improves the sustainability of farming enterprises by reducing deep drainage and subsequent groundwater recharge. Improving Lucerne cultivars could overcome some of its limitations as a forage crop.

These are the high seed cost associated with low seed yields, lack of persistence under unsupervised grazing, intolerance to acid and wet soils, and difficulties in establishment.

Project
The Lucerne Core Breeding Program develops improved, multiple pest and disease resistant cultivars targeted for the key Lucerne growing zones of Australia including the sub-tropics, coastal, cool wet, high rainfall and cereal districts. MLA, the South Australian Government, and the Dairy Research and Development Corporation support the program. Heritage Seeds is the commercial partner.

Septre, Jindera and Eureka are varieties of Lucerne that were released in the 1990s, with investment from the Meat Research Corporation (one of the statutory meat industry bodies that were replaced by MLA). Those varieties have since been replaced with SARDI 10 and SARDI 7. Varieties to replace SARDI 10 and SARDI 7 are under development, with seed multiplication occurring now.

MLA contributes its share of loyalties from seed sales to further Lucerne development. This reinvestment has enabled ongoing development of cultivars and has assisted Heritage Seeds in delivering the new seeds to the market.

Outcomes

Objective industry benefits
Producers have had access to improved Lucerne cultivars that met their production and natural resource management needs. Over the past decade Lucerne seed sales have increased relative to other major species. Heritage Seeds estimate that the SARDI lines would occupy 13% of the Lucerne market, which comprises some 40 varieties.

Intangible benefits
A productive relationship with an “input” supply chain has developed. Public - private relationship between SARDI and Heritage Seeds provides an understanding to the breeders of the downstream issues that affect commercial outcomes (eg, seed production capability).Heritage Seeds also undertakes merit testing. Post-breeding evaluation data is being presented back to the breeders.

Triple bottom line

Economic
Using improved cultivars of Lucerne improves livestock production and reduces the costs of pasture management.
Social
No social benefits have been identified.

Environment
Lucerne has been shown to lower water tables. This assists the management of salinity.

Future
The benefits of using Lucerne will continue to be promoted to producers.

3.2.4 Case study: Drought tolerant white clover cultivar for dry margins

Issue

White clover (Trifolium repens) has been the main perennial dryland pasture legume in the high rainfall temperate areas of Australia with high levels of adaptation. Very successful during the right growing conditions, white clover did not perform as well during drought conditions. A locally bred cultivar was needed that could withstand summer heat and moisture stress, close grazing, grass competition, pests and diseases. Adaptive cultivars would potentially extend the white clover zone and increase productivity and profitability of sheep and beef enterprises into the dry margins (that is, country with 700-850 mm average annual rainfall). It would also provide for greater reliability in the existing white clover zone that is experiencing more frequent seasonal droughts and the increasing threat of climate change.

Project

From 2004 - 2008 an MLA Donor Company project developed, undertaken by the NSW DPI/Ag Research "White Clover Alliance" with PGG Wrightsons and MLA.

The national white clover breeding program has already delivered three reliably persistent cultivars for the existing white clover zone. Trophy and Saracen have tolerance to summer moisture-stress while NuSiral is a broad adaptation cultivar. NuSiral and Trophy are now commercially available in Australia, and Saracen has been released in Europe with commercial plans being considered in Australia.

These varieties show that high local adaptation can take place which will be a significant factor in developing new generation cultivars for the hot dry conditions expected with climatic change.

Outcomes

Objective industry benefits

The introduction of improved white clover cultivars will extend the clover growing zone to a potential 16 million hectares. It will assist beef and cattle producers in planning strategies to ameliorate future impacts of seasonal drought and climate change. It provides a further benefit as a perennial legume for acidic soils, that is, soils not suited to lucerne. The new varieties are increasing market share with growing seed sales following drought conditions.

Intangible benefits

The development of these cultivars will achieve global significance and provide extended marketing opportunities. Research and commercialisation partnerships (NSW DPI, AgResearch/Grasslanz, PGGW Wrightsons and MLA) enable much greater understanding of the supply chain to improve generation and delivery of materials. This program has pursued an initiative of running breeding projects with commercial cultivars as well as success in publishable scientific experiments. This has improved the knowledge base of pasture agronomy and ecology with a total of 113 published documents including 48 scientific papers.

Triple bottom line

Economic
The introduction of these highly adaptive cultivars will enhance the feed year, mitigate the winter feed gap and provide high quality feed over summer and autumn. This in turn will have benefits for cash flow, reduction in risk and increased capability to produce to market specification.

Social
Increased gross production from grazing enterprises will reduce the need for government funding for graziers in times of market downturn and drought. The potential evening out of cash flow will have a trickle-down effect on seed retailers and agri-businesses that provide support to the grazing industry, strengthening rural communities.

Environment
Increased soil fertility will result through nitrogen-fixing properties of pasture legumes and will reduce the carbon footprint of grazing industries. Perennialisation will decrease the erosion potential in degraded landscapes, decrease siltation, suppress weeds and retain moisture for improved water use. Another benefit will be the rehabilitation of run-down pastures and degraded landscapes through increasing ground cover and improving water balance in the soil profile.

Future
A 10 year plan has been developed for the continued breeding, evaluation and commercialisation of a new generation of white clover cultivars for climate change.

3.2.5 Case study: Leucaena

Opportunity
Leucaena is a tropical shrub with highly nutritive foliage best suited for growing on deep fertile soils where annual rainfall is between 600mm and 800mm. Once established, leucaena is a hardy, nutritious fodder giving annual liveweight gains of up to 250-300 kg/head. Leucaena contains a toxin, mimosine, which is quickly broken down in the rumen to further toxic by-products. These latter toxins can accumulate and severely impact the health and production of affected cattle. Luckily, a specific bacteria, *Synergistes jonesii*, is available as a drench from the Queensland Department of Employment, Economic Development and Innovation (DEEDI) to prevent the problem.
In 2005 about 170,000 hectares had been planted in Queensland by 500-800 graziers. There was an opportunity to extend the growing area of leucaena through improved pasture management and developing psyllid-resistant varieties for higher rainfall areas.

Projects
MLA is undertaking projects with the University of Queensland, DEEDI and private consultants to extend the growing area and productivity of leucaena.

Producer manual
In 2006, MLA published *Leucaena: A guide to establishment and management*, a producer manual prepared by the University of Queensland based on their Leucaena training workshops. As at February 2010, 3,345 copies of the publication had been distributed.

Psyllid-resistant Leucaena

Growing leucaena is not recommended in coastal areas of northern Australia because it is susceptible to psyllids (sap-sucking insects that attack developing shoots and young foliage). The University of Queensland, with support from the MLA, is hoping to release a psyllid-resistant hybrid variety of Leucaena by 2013. This work began in 2002 and was to be completed in 2008. However, the initial breeding program experienced an inbreeding depression for yield, and the subsequent backcrossing program produced lines that are still heterozygous for the psyllid-resistance genes (i.e., they contain both resistant and susceptible alleles for each resistance gene). Additional breeding work is required to remove the susceptible alleles.

Toxicity

There is still some industry concern and/or ignorance on how to prevent leucaena toxicity, and the possible role of subclinical toxicity on production. As a result, MLA has supported the University of Queensland and CSIRO to undertake three activities. These are in vitro testing of the rumen inocculum currently produced by DEEDI; development of a PCR test for *Synergistes jonesii*; and investigation of a number of herds that may have cattle suffering sub-clinical toxicity.

Demonstration sites

Four Producer Demonstration Sites on the Darling Downs, funded by MLA, are showing strong potential for leucaena in southern Queensland. These sites show that, with careful selection of planting areas, there is a strong case for leucaena on the Downs. Here, leucaena typically stops producing for about five months of the year during the cold, compared to three months further north. This has implications for productivity and retaining the rumen bug in the herd year to year.

Addressing nutrient decline

Nutrient decline in soil was found to be significantly reducing leucaena growth and therefore likely to reduce pasture and animal production. A protocol is being developed to establish critical nutrient concentrations in leucaena leaf samples. With such testing of leaf samples, producers will be betters able to develop effective fertiliser regimes.

Outcomes

Objective industry benefits

Land planted to Leucaena has risen from 170,000 hectares in 2005 to 210,000 hectares in 2010. MLA activities as outlined above have supported this expansion.

Triple bottom line

Economic

Leucaena-grass pastures are one of the most productive and profitable options for northern beef producers in suitable growing areas. For example, it is estimated that a leucaena-buffel system, relative to buffel grass can do the following:

1. increase stocking rate by up to 100%,
2. increase annual liveweight gain/head (150 -> 300kg); and
3. increase annual liveweight gain/ha (50->200kg/ha).

Social
No social benefits were identified.

Environment
Leucaena pastures lift soil fertility, including soil organic matter (carbon) and soil nitrogen, and improve the productivity of pasture grasses grown between the leucaena.

Future
The University of Queensland, with funding from MLA, is hoping to release a psyllid resistant hybrid variety by 2013. This will expand the growing area of leucaena into the higher rainfall areas of Northern Australia.

3.2.6 Case study: Biological control for Paterson's Curse

Issue
Paterson's Curse (*Echium plantagineum)* is a dominant pasture weed in temperate Australia that causes loss of pasture production. It can also reduce livestock weight gain and wool production and in severe cases can lead to stock death. Insects can provide a biological control for this weeds resulting in a decreased need for herbicides and an increase in pasture productivity. While not suitable in every context, biological control of Paterson's Curse is highly suited to mixed and grazing enterprises and is far less expensive and a far more environmentally sustainable option than alternatives.

Biological control of Paterson's Curse has been the subject of long-term investment by MLA, Australian Wool Innovation, CSIRO and State Governments in NSW, VIC, SA and WA. Biological control insects were introduced from 1988 and have become established nationally. Four agents were successfully released and monitored across 2,700 weed-infested sites. Since 2007 the focus has been on establishing nursery sites in regions with late and unreliable rainfall, and also improving the competencies of weeds professionals and other collaborators to use biological control.

Project
This project has been highly successful, particularly in the establishment of redistribution networks amongst state departments, weed regulatory officers, landcare and producer groups within each state. Biological control techniques have been adopted and incorporated into weed management systems by wool and meat producers as well as other sections of the grazing industry with at least 2,700 farmers directly involved in the program. In reality the number of re-releases is unknown, as farmers exchange the insects amongst themselves once a nursery site is established. The MLA legacy project has encouraged this by providing producers and Landcare officers with training on establishment of nursery sites.

Releases of biocontrol agents
More than 2,700 releases of Paterson's Curse biological control agents have been made in southern Australia since 1996.

More nursery sites established
A network of nursery sites has been established that will enable the full guilds of agents to be redistributed throughout the areas of Paterson's Curse infestation. Nursery sites have also been established for two biological control agents that are more tolerant of dry

conditions. These nursery sites are strategically placed to ensure ease of redistribution to surrounding areas.

Training program

MLA and Australian Wool Innovation Limited (AWI) initiated a process to empower individuals to build up populations and re-release agents within their own communities. A training program has been delivered across southern Australia, educating 214 weeds professionals and 80 farmers in the collection and release of biocontrol agents as well as the establishing of nursery sites. Sixty-seven field days have been held to train participants receiving first and second editions of the practical CD “A practical guide to Biological control of Paterson’s curse in Australia”. The CD assists the program to continue in a self-sustaining manner without external funding.

Outcomes

Objective industry benefits

Biological control techniques have been extensively adopted and incorporated into weed management systems by wool and meat producers as well as other sections of the grazing industry. Over 2,700 farmers are directly involved in the program. Cost of weed control has been reduced. These producers have a better understanding of weeds in farming systems and of the benefits of an integrated weed management approach incorporating the concepts of biological control, herbicide control, grazing management and pasture renovation. A survey of producers reported a 24% decrease in the weed due to insect agents; 31% average reduction in the use of herbicides; 12% increase in stock production, 9% increase in stock numbers, and a highly visible impact on Paterson’s curse

Benefits reported included lower requirement to use chemicals and reduced or intend to reduce the areas that they aerially spray. Other observations reported include reductions in weed densities and improved pasture performance, improved soil fertility, some reduction in the seed bank, increased stocking rates, reduced stocking deaths which used to result from long term grazing on Paterson’s curse.

Intangible benefits

Most of those producers surveyed that report impacts on their properties, also indicate that they have not only introduced the agents to their properties, but have also altered other pasture management practices at the same time. Therefore attribution of pasture improvement to the insect agents is more difficult.

Experience in biological control procedures may be used by producers and weed professionals in managing other weeds.

‘Spillover’ benefits are inferred as local councils have provided support for the program and sought continuity of funding.

Triple bottom line

Economic

Based on a consideration of the impact of only one agent (the crown weevil), the annual benefits in terms of increased productivity (not including reduced cost of conventional control) is conservatively projected to rise to $73m by 2015. The discounted (5%) net

present value (NPV) of the benefit-cost stream from 1972 to 2015 is projected at $259 million. The NPV of projected benefits from biological control (using a 5% discount rate and counting the benefits out from 1972 to 2050), when converted to 2004/05 dollar terms, is approximately $1.2 billion, with a Benefit Cost Ratio of 52.0. Anecdotal evidence indicates that the observed impact of biocontrol accords with this projection.

Social
This long-term collaborative program has assisted in developing strong links between agencies, producers and weed professionals.

Environment
Less chemical use benefits the environment.

Future
Four agents are being established in many locations across southern Australia. Due to reasons such as drought, populations of the agents decline. Some locations in drier areas do not have agents present. However, with the network that has been established and access to methods to develop nursery sites, re-releases will continue ensuring the maintenance of core populations.

3.2.7 Case study: Biological control of Parkinsonia weed

Issue
Introduced in the nineteenth century, parkinsonia (*Parkinsonia aculeate)* now inhabits almost 1 million hectares in northern Australia and threatens to spread across more than three quarters of the mainland. It forms dense, impenetrable thorny thickets and is found along watercourses, bore drains, floodplains and grasslands. Affected properties suffer reduced carrying capacity and incur significant control costs, with some large properties spending over $100,000 per year on control.

Projects
MLA, CSIRO, the Queensland Department of Primary Industries & Fisheries and the Australian Government (Defeating the Weeds Menace Program) have collaborated to find biological control options for parkinsonia. Biological control is the process of introducing natural enemies of exotic weeds or other pests into an infested area, to reduce their growth, reproductive capacity or life expectancy. In this project researchers have surveyed addtional areas throughout South America, identified hundreds of potential biological control agents, and assessed their potential for release in Australia.

Three agents for parkinsonia have been identified that have a high probability of being suitable for introduction into Australia. This short-list was determined after the careful screening of a large number of organisms both in the field and in the laboratory in Mexico and Argentina. We are now ready to begin the next phase of this project which is to complete the evaluation of the insect species in Australian quarantine.

Outcomes
No immediate impact will result from the work covered in this project as the time frame for biocontrol projects is very long. However, in five years time impacts are expected to accrue. Two to three new biocontrol agents of parkinsonia are expected to be released into the Australian environment. It may take many years for the full impact of the released agent to be realized. However, once in place, the benefits are self-sustaining,

permanent, ecologically non-damaging, economically beneficial and do not require the continuous input of land managers.

Triple bottom line

Economic
In densely infested areas, parkinsonia control and management can cost properties over $100,000 per year. Identification and release of an effective biological control agent for parkinsonia has potential to save the industry millions of dollars in direct control costs (up to $400 per ha) and lost productivity. This release will produce net present value (NPV) benefits to industry of $46 million, a 28% internal rate of return (IRR) on invested funds and a benefit to cost ratio of 4.4.

Social
Reduced weed management inputs, and increased environmental and tourism value in important habitats and ecosystems.

Environment
Successful control of parkinsonia will have important environmental benefits as it is a weed that aggressively invades sensitive and valued ecosystems and habitats such as wet-lands and riparian areas.

Future
Two control agents have been imported into Australia for host specificity testing, with importation of a third underway.

3.2.8 Case study: Sustainable grazing on large cattle properties

Issue
On very large cattle properties, cattle grazing can be very uneven. Paddocks are large and watering points are scattered. As cattle need to return to water regularly, some areas tend to be overgrazed while others are underused. In large paddocks (50-100 km^2) this limits stocking rates and can increase land degradation, further limiting carrying capacity over time.

Project
The world's largest sustainable grazing trial was conducted between 2002 and 2007 at Pigeon Hole Station, south of Katherine in the Victoria River District (VRD) of the Northern Territory (NT). Pigeon Hole Station has an area of around 320 $km^{2.}$. An adjoining property, Mt Sanford Station, was the site of a supplementary study on pasture utilisation rates.

The project found that intensifying infrastructure is becoming more cost effective than acquiring more grazing land as a means of increasing overall carrying capacity. Intensifying infrastructure means building more fences to sub-divide large paddocks and putting in more water points. Data was developed about optimal paddock size and distance from water to optimise grazing. Results indicate that, on the black soil country of the VRD, producers should aim for paddock sizes of 30-40 $km^{2,}$ with two watering points per paddock. After monitoring set-utilisation rates ranging from 14 to 40%, it was found that up to 20% annual pasture utilisation is sustainable.

Producers in the Northern Territory have been informed of the findings of this project, with 23 properties, covering an area of around 72,000 km^2, being represented at a major Field Day at Pigeon Hole Station in 2007. Producers from Western Australia and Queensland also attended.

The project was undertaken with Heytesbury Beef, CSIRO, NT Department of Regional Development, Primary Industry, Fisheries and Resources, NT Department of Natural Resources, Environment and the Arts, Observant Pty Ltd and University of Queensland.

Outcomes

Objective industry benefits

Producers have grazing and infrastructure guidelines to improve the economic performance of their beef cattle enterprises, and also maintain range condition and minimise impacts on biodiversity. Newer technologies such as telemetry for remotely managing water points have also been tested. Most properties in the region are implementing, or developing plans to implement, intensification of infrastructure especially with respect to installing additional water points.

Triple bottom line

Economic

The project showed that a more intensified system is more efficient and has a lower cost of production. This increases a beef business's return on invested capital from a typical 5-6% to over 10%.

Around half the properties in the VRD have the potential for intensification. Intensification of these properties could see an increase in cattle numbers, generating an additional annual gross margin of about $17 million.

Social

The project has provided many producers in the NT with confidence in the potential for their beef businesses to continue to grow and remain viable in the longer term. More profitable and sustainable beef properties help underpin the region's communities and services.

Environment

Producers minimise the environmental risks to their properties of soil loss and decreasing biodiversity by not exceeding a 20% pasture utilisation rate. The management guidelines also provide measures to help ensure biodiversity in the region is conserved.

Future

Ongoing work in the Northern Grazing Systems Initiative is continuing to demonstrate, evaluate and extend the findings from the Pigeon Hole project with producers in the VRD and Barkly regions.

3.2.9 Case study: Rangelands educational program

Case study: Rangelands

Opportunity
The Australian rangelands are vast grasslands, shrublands, woodlands and savanna that comprise around 80% of the country. Around 60% of the rangelands has 6000 pastoral enterprises (www.rangelands-australia.com.au). Despite the importance of the rangelands, no educational program existed, that addressed issues specific rangeland management.

Project
With partners, MLA developed an educational program that addressed the current and emerging issues for producers and Natural Resource Management/Landcare professionals in the rangelands. The program, called “Rangelands Australia”, focuses on professional development and increasing students’ capacities to run profitable enterprises, and contribute to better environmental and social outcomes.
The program has twelve range-specific postgraduate level courses. Courses are offered on campus at the Gatton campus of the University of Queensland, externally and through intensive blocks at strategic locations. The program also offers short courses.
Participation in courses has grown strongly, with the program exceeding student numbers of all other postgraduate programs in the University of Queensland’s faculty of Natural Resources, Agriculture and Veterinary Sciences. Course evaluations are favourable with the courses rated as high quality, relevant and practical.

The first phase of this program ran from 2001 to 2005, with support from the University of Queensland, CSIRO and MLA. The current phase has run from 2006 to 2010, with support from the University of Queensland, the Australian Government’s Department of Agriculture, Fisheries and Forestry; the Queensland Government’s Departments of Tourism, Regional Development & Industry; Primary Industries and Fisheries; and Natural Resources & Water, the Foundation for Rural and Regional Renewal and MLA.

Outcomes

Objective industry benefits
Rangelands Australia students are better equipped to undertake their various roles in managing Australia’s grazing lands.

Intangible benefits
Participant are more confident in dealing with stakeholders, are more effectively communicating and working with others, and have a greater interest in learning. The students’ improved perception of higher education may improve rates of rural people undertaking university studies in the future.

Triple bottom line

Economic
Participating land managers and NRM professionals report that they have a greater understanding of their external environments, and a greater ability to solve problems, manage people, make decisions and undertake strategic planning. They also report that

they have changed management practices, saved money, and are running their enterprises more efficiently and managing their resources more sustainably.

The resulting improvements in animal production, herd improvement, land condition, water use and biodiversity, diversification of income, and social cohesion will improve the economic performance of their various enterprises.

Social
This program has provided personal growth and professional opportunities for people in regional Australia. Participation in the courses has expanded networks, and students have been encouraged and prepared to take on industry and community leadership roles.

Environment
Land managers and NRM professionals are reporting improved environmental outcomes such as more water retained on their properties, cleaner runoff and improved species diversity.

Future
MLA's funding of Rangelands Australia has now stopped. MLA will continue to work with the University of Queensland to develop courses and post-graduate programs that will contribute to the skills and knowledge of rangeland managers.

3.2.10 Case study: Pastures Australia Management Agreement

Opportunity
Technologies, tools and management systems that help Australian producers make the most of pastures are important. Pastures contribute about $13.4 billion annually to the national economy through animal production and improved crop rotations. Pastures increase land carrying capacity, control erosion, boost water use efficiency and contribute to sustainable land use. Pastures also provide Australian livestock producers with a major competitive advantage over many overseas animal production systems that rely on grain and stored fodder.

The pasture industry supply chain provides goods and services to livestock producers from varied sources. These include seed companies, wholesalers, retailers, input suppliers and advisors. Information exchange between these industry sections has been problematic. Consequently producer benefit from MLA investment in pasture related technologies is not ensured.

Project
An industry-wide collaboration since 2006, Pastures Australia aims to increase value for farmers from research, development and extension of improved pastures. Success requires improved information exchange along the supply chain, and can only be achieved with improvement in coordination and communication to all the different stakeholders in pasture industries.

Pastures Australia (PA) is a joint venture of MLA, Grains Research and Development Corporation, Australian Wool Innovation, Dairy Australia and Rural Industries Research & Development Corporation, with development assisted by state departments of agriculture and primary industry. Pastures Australia, with centralised funding from the

RDC partners, conducted research, coordination and delivery initiatives to improve processes and content that would contribute to goods and services being provided to producers.

Pastures Australia's key achievements to date include:

- Undertaking market research to understand the needs and opportunities in the pasture supply chain.
- Promoting advanced breeding technologies with seed companies.
- Piloting a regional variety testing program with seed company funding
- Fostering a network, supported by seed companies, to work towards sharing of data and devising reporting protocols for performance of pasture varieties.
- Developing advisor and producer tools. For example, the Pasture Picker website allows producers and advisors to assess the most suitable pasture varieties for their region and purpose. The Phosphorus decision tool can help to determine suitable levels of P-fertilisation for temperate pastures.
- Releasing two sub clover varieties with resistance to red-legged earth mite, one medic variety, and one sulla legume variety.
- Producing agronomy and management guidelines from current projects (for Sulla and pasture legumes).
- Engaging more than 1,000 producers in new pasture technologies
- Pasture Updates for technologists, advisors and producers
- Formation of a pasture industry supply chain reference group representing the various stakeholders that develop an delivery goods and services to producers

Outcomes

Objective industry benefits

Improving communication of existing and new research and development is assisting producers to better manage their pastures.

Intangible benefits

Interactions between MLA and the pasture industry supply chain (eg, seed companies, seed wholesalers and retailers) has created opportunities for MLA to influence and cooperate with these stakeholder to assist adoption of new technologies and delivery information to livestock producers.

Triple bottom line

Economic

Improved breeding technologies and regional evaluation can provide a four-fold gain in genetic improvement and confidence in the performance of pasture varieties in regional locations.

Social

Members of the supply chain better understand MLA's, and each other's, roles and activities.

Environment

Improved adoption of adapted pasture varieties fit for land class and purpose will reduce soil erosion,and increase capture of nutrients and water.

Future
MLA is developing initiatives from the PA program, such as the following:

- A 'Pasture genetics made easy' booklet for retailers.
- Scoping an auditing and accreditation system with seed companies, based on updated trial protocols jointly developed between MLA, the Australian Seed federation, and seed companies.
- A series of Pasture Updates (for technologists, advisors and producers) is being implemented across southern Australia.

3.2.11 Case study: Sustainable grazing on saline lands

Issue
As much as 2.5 million hectares of Australian agricultural land is estimated to be affected, or at risk of dryland salinity. Dryland salinity results in large losses of production and biodiversity. Salt also affects water sources, reducing water quality and placing the health of streams and lake perimeters at risk.

Project
The Sustainable Grazing on Saline Lands (SGSL) project, undertaken from 2001-2007, was a major component of the Land Wool & Water project that examined key natural resource issues faced by woolgrowers in a commercial context. Land Water & Wool was an initiative of Australian Wool Innovation Ltd and Land, Water & Water Australia. The SGSL component, co-funded by MLA, aimed to utilise already salinised land to its productive/profit potential for livestock production; reduce the negative environmental impacts associated with saline land; and restore livestock producers' personal pride in their property, their management and their product, through increased productivity, visual amenity and financial value of their salinised land.

Large producer network
This project facilitated the development of a network of 1250 producers with salinised land. The network helped producers to share and build on local knowledge and experience and set local priorities for action and to develop and test practical solutions. The network supported farm practice change and linked producers with relevant research projects.

New tools and information
This project developed or refined a range of new tools and information packages to address saline land. The direct value of incorporating saltland pastures arose from the direct value of the additional feed produced, often out of season and seasonal resting of land not affected by salinity from grazing after the break. New tools and information conveyed the benefit of management packages, case studies on how farmers are successfully managing saltland for profit, impacts of management systems on soil and invertebrate biodiversity, practical guides for salinity management, information on identifying relevant plant species ('SaltDECK'), and an interactive website, 'Saltland Genie', to help producers find out the best ways to make money off their salt-affected land.

Outcomes

Objective industry benefits
Rehabilitated saltland pasture provides extra feed from land that was previously unproductive. Extra value from the feed is derived as it is often available late in the season as salty sites are usually wetter.

Intangible benefits
Producers who rehabilitate salty land report an increase in the pride they feel in their properties.

Triple bottom line

Economic
Saltland pastures can yield around $4,000 a year extra on a 2,000 hectare farm. This is equivalent to $80/ha of saltland pasture, based on revegetating 50 hectares of moderately saline land. This is based on whole farm modelling from the southern WA wheatbelt. As the area revegetated widened to include mildly and severely affected saltland (115 ha in total) the average profit of saltland pasture decreased to $40/ha.
In addition, reducing amount of salt affected land on a property can increase the property value.

Social
Producers in the SGSL network group no longer felt isolated in dealing with their salinity problems. They increased their confidence and capacity to deal with saline land.

Environment
Pasture establishment on land that is affected by salinity can reduce the amount of salt entering adjacent soil and waterways. Pasture also uses more water thereby reducing run-off and lowering the watertable, assisting overall rehabilitation of the affected land. Biodiversity increases on rehabilitated saltland pastures.

Future
The Future Farming Industry CRC has developed SGSL output in their Saltland farming systems.

3.2.12 Case study: Better Fertiliser Decisions

Issue
The nature of Australian soils means fertiliser is critical to overcome nutrient deficits. Fertilisers containing nitrogen (N), phosphorous (P), potassium (K) and sulphur (S) will continue to be a key requirement for the Australian grazing industries. However, increased community concerns about excess nutrients in water and the atmosphere means that farmers and service providers need to have access to, and use, the best possible information regarding optimum nutrient management practices for environmental as well as productivity benefits. Fertiliser is a major cost to grazing enterprises and if not used efficiently, can be lost from the system, forgoing pasture and animal benefits as well as affecting the environment negatively through excess nutrient run-off. Although many aspects of fertiliser management have been well understood for a

while, the information was fragmented and had not been combined to provide producers with comprehensive information.

Project

The Better Fertiliser Decisions project, undertaken in 2003 - 2007, consolidated existing information, worked with stakeholder groups and delivered comprehensive, new and improved technical information and tools to industry and nutrient specialists across Australia. The project provided regionally specific and scientifically validated fertiliser-pasture production responses for various pasture types, climatic zones and soil types. It also better defined fertiliser management practices that account for nutrient loss processes and pathways. The project also integrated production and environmental information into materials and tools that can assist industry and government networks including fertiliser company advisers, environmental agencies, consultants, extension officers and farmers. This was achieved by the project researchers collating and re-analysing more than 250 experiments across 1600 sites and more than 48,000 individual pasture measurements.

The project was funded by Dairy Australia, Meat & Livestock Australia, Land and Water Australia, the Fertiliser Industry Federation of Australia, fertiliser companies and state agencies.

Soil test – pasture response relationships

The project determined a series of soil test –pasture response relationships for P, K and S that can be used at regional, state or national levels, or according to soil texture or the soil's phosphorus-fixing properties.

Phosphorous

The project has delivered the most comprehensive collation and summary of soil test calibration studies for pasture production ever undertaken in Australia, and probably internationally.

The project also discovered a radical simplification to measure phosphorous. Historically phosphorous measurement has required complex Colwell P equations. This information allows producers and their advisors to assess phosphorus rates from Colwell P tests based on one main criterion, the phosphorus buffering index (PBI) of the soil, and determine if pastures are being over or under fertilised based.

This work on phosphorous was later used by MLA, CSIRO, Pastures Australia and other partners in 2009 to develop the guide, *Five easy steps to ensure you are making money from superphosphate.* This booklet is relevant for the management of temperate legume-based pastures grazed by sheep and beef cattle on acid soils in southern Australia.

Farm Nutrient Loss Index (FNLI) tool

The BFD project developed a Farm Nutrient Loss Index (FNLI) tool. This tool raises alerts if the proposed nutrient applications may end up running off site (which has cost and environmental impacts). FNLI allows fertiliser recommendations to be better tailored to particular soil types, land characteristics, enterprises, waterways and annual rainfalls. The information can then be used to modify management practices, so farmers can optimise fertiliser efficiency and at the same time reduce potential losses of phosphorus and nitrogen. FNLI has been developed into the E farmer program associated with while farm planning. It has been incorporated in the Fertcare industry QA program

Booklet and CD for producers
A booklet for producers, advisors and field officers was produced that explains the soil test–fertiliser response relationships and the FNLI. The booklet is accompanied by a CD with the FNLI program and user manual.

Database for fertiliser specialists
There is also a national database for fertiliser specialists containing the data submitted to the project.

Outcomes

Objective industry benefits
Producers using the BFD tools and information improve their soil fertility, manage cost of fertiliser, and reduce nutrient losses from their pastoral land to ground water, waterways and the atmosphere.

Intangible benefits
A national database containing all the information generated and collected by the project now exists. The website also allows ongoing access to the decision support tools, and can be updated if further information becomes available.

The fertiliser industry has incorporated soil nutrient responses and the FNLI tool into the FertCare accreditation course, the industry Quality Assurance (QA) program. The fertiliser industry has also welcomed the BFD database. There are currently around 70 ‘Fertcare Accredited Advisors’, nearly 1,000 advisors have completed Fertcare Level C training, and more than 1,400 other staff are completing Level A and Level B training. The fertiliser industry expects to have around 85% of members’ staff trained at the appropriate level of Fertcare by the end of the 2010.

Industry training and state department extension programs have also used BFD data in their material, assisting the fertiliser and grazing industries to obtain full benefits from the research.

Triple bottom line

Economic
Fertiliser is a major cost to grazing enterprises. This project and follow-up processes with the industry driven Fertcare QA program, underpins improvement in advisor recommendations and subsequent producer benefits, through increased efficiency and appropriate use of fertiliser.

Social
The project has facilitated the creation of active network of nutrient experts from across Australia.

Environment
Better use reduces nutrient fertiliser affecting into the surrounding environment and atmosphere.

Future
MLA has developed a “Soil P RD&E program”. The data from BFD, the tools will be a core component of a delivery program across southern Australia focussing on soil testing and appropriate fertiliser applications. This will reduce in many cases cost of production. MLA will continue to work with input suppliers in the pasture industry supply chain to improve delivery of information to producers.

3.3 Improving delivery and capacity building

3.3.1 Case study: Beef Up forums

Opportunity
Beef producers in northern Australia could improve the profitability and sustainability of their businesses by accessing and applying the results of recent research and development.

Project
Beef Up is a program of one day forums that have run throughout northern Australia for beef producers since 2006. The forums provide information and tools that can make a real difference by focusing on the key profit drivers of beef enterprises. Producers can also engage with presenters and other expert advisors and get advice on follow-up support and training.

Each forum covers how to improve business management, grazing land management, liveweight gains and reproductive performance. Other areas include industry issues and a northern Australia R&D update. Each forum has a regional topic (succession planning, Meat Standards Australia) that is identified in conjunction with the local Regional Beef Research Committee.

Beef Up forums are a collaborative initiative of MLA and the government departments in Queensland, Northern Territory and Western Australia with support from Symbio Alliance, Rangelands Australia, Elders, Landmark and AgForward.

Outcomes

Objective industry benefits
Since 2006, over 2,500 producers have attended one of 51 Beef Up forums. Over 12% of the 18,000 northern beef producers have attended a Beef Up forum between 2006 and 2010. These producers manage well over a quarter of the northern beef herd.

Forum evaluations show that northern Australian beef producers are more knowledgeable of industry best practice. Well over 90% of producers who have attended Beef Up forums indicate they learn something new, with around a quarter (605 people) saying they intended to make changes in management from what they learnt at Beef Up. The most common areas identified for change were business management, breeding, heifer and bull management, grazing land management, people management and nutrition. Of these producers, around half have already implemented changes.

Intangible benefits
Producers have more awareness of other training opportunities.

Triple bottom line

Economic
Any economic benefits have not been documented.

Social
Relationships have been strengthened between beef producers and industry specialists.

Environment
Any environmental benefits have not been documented.

3.3.2 Case study: Making More from Sheep

Opportunity
There is a large volume of information and tools that sheep producers can use to increase the productivity, profitability and sustainability of their enterprises.

Project
The Making More from Sheep (MMfS) program consolidates the best information and tools available for lamb and sheep producers, delivered through a reference manual, dedicated web site and events such as workshops and industry forums. The manual collates a large amount of useful information about managing a successful sheep and/or wool enterprise. This information has been generated by many years' research and development as well as on-farm experience. The manual has eleven modules that are linked to enterprise profit drivers. These include improved genetics, healthy soils, productive pastures and planning tools. Launched in January 2008, MMfS was developed by MLA with AWI and 250 leading sheep and wool producers and technical experts. About 6,000 farmers have taken part in forums, workshops and other MMfS activities, with more than two thirds (71%) of Australian sheep producers aware of the program.

Outcomes

Objective industry benefits
Around half (46%) of MMfS participants said they had made a practice change as a result of their participation in the program (GHD Hassall 2009). Producers considered that these changes have contributed to their enterprises' productivity and profitability increases. Improved grazing management was nominated by approximately 60% of producers to have led to management improvements. Forty four percent of producers estimated production increases up to 20%.

Intangible benefits
This national program with state level coordination has enabled improved and more consistent communication to stakeholders. State coordinators showed a strong sense of ownership of the program, illustrated by their willingness to bundle many of the own activities under the MMfS name

Triple bottom line

Economic
A survey of participants found 39% of respondents reported an increase in profitability as a result of their involvement in the MMfS program. The main factors identified as leading to an increase in profitability included pasture and grazing management and improvement in lambing weaning rate.

In 2009 the present value of total benefits of MMfS was estimated to be $6.9 million, calculated at a discount rate of 7%. This equates to benefit of around $1,630 per enterprise.

Social
The MMfS program motivates producers to improve their skills and knowledge. It also gives producers reinforcement for good management decisions that are already in place.

Environment
More than half of participating producers (55%) are better able to manage natural resources as a result of involvement in the MMfS program. The main natural resource management benefits gained from involvement in the program include increased pasture ground cover (43%) and better assessment of land capability (32%).

Future
MMfS is ongoing. Information will be tailored to producers' needs, and delivered through workshops, forums, mentoring and coaching activities.

3.3.3 Case study: EDGE*network*®

Opportunity
Existing and emerging knowledge from livestock production research and development can assist producers increase the profitability and sustainability of their enterprises.

Project
MLA's EDGE*network* is a national program of practical learning opportunities to help producers gain knowledge and develop skills necessary to improve their livestock enterprises. *EDGEnetwork* has been running since 2000. Delivered through workshops, farm walks, demonstrations, group discussions and projects, EDGE*network* sessions enable producers to apply various business practices and principles, as well as outcomes from industry research and development, directly in their production environment. Around 18,000 producers have participated in EDGE*network* workshops since 2000, 8440 of whom have taken part since 2005. The EDGE*network* concept is jointly owned by MLA and the Department of Primary Industries Victoria. Offering a diverse program, EDGE*network* develops courses that are specific and relevant for different groups of producers. As examples, BeefCheque and Grazing Land Management are two programs for beef producers, customised respectively to southern and northern Australian contexts.

BeefCheque®

Starting in 1995, BeefCheque has been highly successful EDGE*network* course. Groups of Victorian beef producers participate in year-long group workshops to improve their skills in grazing management. Prior to 2005 over 1000 beef businesses took part in BeefCheque. Since 2005, a further 1115 producers have taken part. Each group meets around once a month, usually at a member's 'focus farm'. The producers control their group's agenda. Farm walks are undertaken with an expert consultant, with the group discussing what is to be done on that property. Future meetings discuss the results of these decisions.

Grazing Land Management courses for northern Australia

The EDGE*network* Grazing Land Management (GLM) education package in northern Australia compiled of a range of information on land management issues for this region for the first time. The development of this region-based courses enable local land managers to easily and readily identify the effects of land type, land condition, climate variability and other management issues which affect their businesses. Since 2005, 835 people have taken part in one of 78 workshops. Courses have been developed for the following areas: Border Rivers, Burdekin, Central Australia, Channel Country, Desert Uplands, Far North Queensland, Fitzroy Basin, Katherine, Kimberley, Mackay/Whitsunday, Maronoa Balonne, Mitchell Grass Downs, Mulga, Northern Gulf, South East Queensland, Southern Gulf and Barkly Tablelands.

Outcomes

Objective industry benefits

EDGEnetwork has increased producer knowledge, skills and confidence to improve their management practices. Ninety two percent of participants said the activity had a positive impact on their business.

BeefCheque has increased the knowledge and confidence of southern Australian beef producers to apply pasture management principles. The Northern GLM program has assisted northern beef producers improve their grazing practices. Survey results from the Desert Uplands workshops are indicative, with 74% of participants having a GLM Plan after training and 64% of participants changing grazing practices as a result of attending the GLM course.

Triple bottom line

Economic

EDGEnetwork has increased producer knowledge, skills and confidence to improve their management practices.

A study of northern beef producers who participated in EDGEnetwork from 2007-2009 indicated that an additional 7.5% per annum increase to net cash income on farms will be generated that is attributable to resulting changed management practices. This finding included practices changed by involvement wth Frontier (a publication) and the program Beef Up as well as Producer Demonstration Sites.

Social

EDGEnetwork has increased producers confidence to adopt new management practices.

Both BeefCheque and the Northern GLM program use group based learning techniques which assist producers make links, both with each other and regional specialists.

Environment
Improved farm management practices results in better natural resource management. As an indication, producers who attended the Desert Uplands workshop believe the workshops have already, and will continue, to deliver significant Natural Resource Management benefits at the property scale, sub-catchment scale and regional scale.

Future
EDGE*network* is an ongoing program.

3.3.4 Case study: More Beef from Pastures

Opportunity
The fundamental drivers for improving productivity and profitability across the southern beef industry have not changed over the last 20 years. Effective and efficient use of the feedbase remains the key driver for productivity and, in the context of efficient use of other physical resources (including labour), continues to provide the greatest opportunity for improvements in enterprise profitability thereby enabling an increase in throughput (animals and kilograms of beef per hectare) live weight turn off and hence productivity and possible profit gains.

Project
More Beef from Pastures is a program that delivers relevant research and development findings to beef producers in southern Australia.

Running since 2004, the program encompasses a producers' manual, tools, events and other activities. A network of state co-ordinators and producer advocates is available to assist with program delivery and adapt key messages to different regions.

Since the program commenced, more than 20,000 people have attended program events, including repeat attendees. Estimates are that at least 10,000 beef cattle businesses have participated. Events have been held across five states, with approximately 200 workshops and 22 expos. More than 4,000 producer manuals and 18,000 CDs have been distributed.

The Producers' manual addresses different aspects of the production system in southern pasture-based beef enterprises. This includes topics such as setting business direction, pasture utilisation, cattle throughput and meeting market specifications. Written under the guidance of producer representatives by industry experts, the manual is a step-by-step guide to getting the key principles and practices that enable a profitable and sustainable business. There is both hard copy and CD versions available of the manual along with a number of decision support tools.

Outcomes

Objective industry benefits
More than half of course participants surveyed (55%) were influenced to change management practices as a result of course attendance, with producer surveys confirming that practice changes had occurred and that these changes were thought to

have contributed to enterprise productivity and profitability increases. For example, improved grazing management was nominated by approximately 60% of producers to have led to management improvements. Forty one percent of MBfP producers estimated production increases ranging from 0-5% to greater than 20%, while 28% estimated profitability increases ranging from 0-5% to 15-20%.

More than a quarter (28%) of respondents reported that their involvement in the MBfP program has led to an increase in profitability. 'Pasture production' (48%) and 'more beef sold/better quality' (17%) were the major factors leading to an increase in profitability.

Intangible benefits
Producers using the MBfP manual are better able to implement new technologies as they emerge.

Triple bottom line

Economic
The net present value (NPV) of the MBfP program to date is estimated to be $12.51 million with a corresponding benefit cost ratio (BCR) of 4.35.

Social
Many participants (59%) who were surveyed felt more motivated to improve their knowledge and skills after participating in the program. Producers also said that they began to think more about planning for the future; heard about new ideas and information; and had a more positive attitude about implementing what they had learnt.

Environment
Around half (49%) of survey respondents reported that their involvement in the MBfP program had helped them to better manage natural resources on their property. The most common on-farm benefits identified by respondents included increased pasture groundcover, better assessment of land capability; and integrated pest and weed management.

Future
As new and better tools emerge they will be incorporated into the MBfP framework.

3.3.5 Case study: Producer Demonstration Sites

Opportunity
Producer participation in trials stimulates adoption of findings from current research and development.

Project
MLA funds Producer Demonstration Sites (PDS) to support producer groups and extension staff to demonstrate, develop and adopt MLA research findings and technologies as well as seek research and development solutions to on-farm problems. Funding of $20,000 over three years is awarded to successful applicants.

Through the PDS program producers are provided with a practical environment that enables them to share experiences and participate in the commercial application of research outputs in the following areas:

- Grazing land management (northern projects)
- Pasture and grazing management (southern projects)
- Weed management
- Improving liveweight gain
- Improving reproductive performance
- Animal health and welfare
- Enhancing enterprise efficiency

The PDS program follows the PIRD® (Producer Initiated Research and Development) program which started in 1992. MLA continues to support a number of PIRD projects, although PIRDs are being phased out in favour in Producer Demonstration Sites. The PDS program improves on the PIRD program by enabling more rigorous project design and producer support.

More than 28 groups are running trials and demonstrations in areas such as pasture management, pest control and beef finishing systems.

Outcomes

Objective industry benefits
The PDS program currently involves more than 700 producer participants. These participants typically extend their learnings to other producers.
In 2010 67% of producer participants said they have changed a management practice as a result of their involvement in a PDS or PIRD.

Intangible benefits
MLA receives valuable information about where producers are seeking knowledge through funding applications.

Triple bottom line

Economic
No economic benefits have been documented.
Social
Producer participants have built networks with each other and relationships with researchers.

Environment
Trials involving natural resource management have resulted in environmental benefits.

Future
The program is ongoing.

3.3.6 Case study: Postgraduate scholarship program

Opportunity
Enhancing the future capability of scientists in the livestock research community will benefit the red meat industry.

Project
More than 220 postgraduate students have been supported by MLA and its predecessor organisations since 1975. The scholarship program supports students doing postgraduate studies for the first three years of their candidature. These students receive a higher stipend than the Australian Postgraduate Award as well as support for project costs. Students' projects are diverse and include all areas of MLA's on and off-farm R&D programs. Since 2005 MLA's overall investment has increased and scholarships have focussed on postdoctoral fellowships. A number of the past and current leaders in livestock R&D have been recipients of scholarships, for example Bernie Bindon, Ian Johnsson and Alex Ball.

Outcomes

Objective industry benefits
Around 75% of MLA scholarship recipients have made high-level contributions during their careers and around 79% are still involved in the red meat industry and other sectors of Australian agriculture.

Intangible benefits
Whilst there is no direct measurable benefit from scholarships, economic benefits are derived from developing future project leaders.

Triple bottom line

Social
MLA builds long lasting links to future researchers.

Future
The program is ongoing with an intake of around 10 students each year.

3.3.7 Case study: Attracting and retaining staff

Issue
Australian pastoral livestock industries are labour intensive and a number of factors have lead to high staff turn-over and general staff shortages. These factors include a strong mining sector, expansion of the services sector, slowing of population growth and an aging workforce. Being able to attract and retain good staff is fundamental to the sustainability of beef and sheep production systems.

Project
In 2008 MLA and Australian Wool Innovation Limited (AWI) undertook research to understand how to attract and secure a skilled and stable labour force. The research is the first in Australia to consider attraction and retention of staff from both the employer and employee perspectives. In total, 842 individuals participated, comprising 245 employers and 544 people from rural properties.

The project identified the drivers of attraction and retention for each of the pastoral livestock industries of Northern and Southern Beef, Pastoral Wool and Lamb and Sheep meat.

The project found that:

- Pastoral industry employees are highly engaged even though the industry is facing challenges attracting and retaining staff.
- Pay is not the only motivator for staff.
- Teamwork, career development and training are key drivers influencing employees to remain with their employer.
- Coordinated marketing to promote lifestyle benefits, community, job variety, career paths and current high levels of job satisfaction could attract new staff to the pastoral industry.
- Focus on fair-pay, training, career, long-term job stability and better communication to keep staff in the role longer.

Future

Fact sheets on this project are being produced and will be ready for distribution by the end of 2010.

3.3.8 Case study: Wean More lambs

Opportunity

There are a number of management practices that have the potential to increase productivity and profitability for sheep producers. Demonstrating those benefits through on-farm trials to producers is one of the key components of encouraging adoption of the practices.

Project

MLA established trial sites across Australia from 2005 to 2006 to demonstrate the cost benefits to producers of best practices that would lift productivity and profitability through increased lamb conception, survival and weaner weight gain. Best management principals included:

- Supplementary feeding to optimise reproduction.
- Pregnancy scanning ewe for improved allocation of feed.
- Controlling predation.
- Lambing time.
- Ewe temperament.

Of the 12 sites that completed their initial management objectives, five achieved an explainable increase in profitability from implementing their altered management system. More than 650 producers attended field days that were held locally across all sites.

EDGEnetwork®

The findings from the demonstration sites were developed into a Wean More Lambs workshop in 2006, as part of EDGE*network*, a program of workshops for producers, jointly owned by MLA and the Department of Primary Industries, Victoria. The workshop covered topics such as the optimum time to wean lambs, the effect of weaning on ewe recovery, sources of reproductive wastage, monitoring ewe condition, ram reproductive health, as well as feeding and management strategies to improve lamb survival.

Making More From Sheep – A sheep producer's manual.

In 2008 the Wean More Lambs findings also became a module in *Making More From Sheep – A sheep producer's manual.* A 2009 survey of producers found Wean More Lambs was one of the most read modules of the *Making More from Sheep* manual. The

'Wean More Lambs' module was also developed as a workshop for producers, delivered by the Making More from Sheep program. It was delivered 65 times in sites across Australia in 2008-2009. Based on this module, courses have been run across Australia on pregnancy scanning of ewes to help improve lamb survival. This continues today with the Sheep CRC pregnancy scanning workshops

Lifetime Ewe Management

Using findings from the Wean More Lambs project, MLA and the Sheep CRC have developed the Lifetime Ewe Management (LTEM) program. Delivered by Rural Industries Skill Training (RIST), this course gives producers the tools and skills to increase stocking rates, wean more lambs per hectare and decrease ewe mortality. LTEM training is delivered over six hands-on sessions over a year, nationally. Over 300 producers that manage almost 2 million ewes have participated in LTEM since 2006. Recent reviews of LTEM indicated that producers who had completed the course had an 11% increase in lamb marking rate and a 4% reduction in ewe mortalities.

Outcomes

Objective industry benefits

By developing and implementing practical technologies and management practices that improve reproductive efficiency of their flocks, producers are growing more kilograms of lamb per hectare.

Producers participating in LTEM have an improved understanding and management of the grazing system and are meeting the condition score targets of the ewe flock over the reproduction cycle. This leads to decreased ewe mortality, increased lamb birth weights and hence lamb survival, and the progeny cutting more wool that is finer.

Changes in productivity from LTEM participants 2005 to 2008

	2005 (pre-LTEM)	**2008 (post-LTEM)**
Stocking rate (dse/ha)	12.2	13.9
Lambing % (crossbred ewes)	111	126
Lambing % (Merino to Merino)	73	84
Lambing % (Merino to other)	82	92
Ewe mortality per annum (%)	4.5	2.5

Triple bottom line

Economic

Producers demonstrated an average benefit of $50 per hectare after participating in Lifetime Ewe Management (LTEM). That included increased lambs weaned ($23.90), stocking rate and ewe wool increases worth $18.70, reductions in ewe mortality ($5.70), and better wool from Merino lambs ($1.10).

Social

One of the outcomes of the LTEM management course was the structured group learning that facilitated better engagement between producers and generated opportunities for the private sector in training.

Environment

One of the outcomes of wean more lambs and LTEM has been the greater awareness of pasture budgeting and the need for effective grazing management.

Future

Research and development findings relevant to managing lambing will be included in the Wean More Lambs module of *Making More from Sheep* and the Lifetime Ewe Management program as they emerge.