final report

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R&D for the meat industry feedbase in southern Australia

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Executive Summary

Three initiatives converged in early 2010 to underpin the need for a formal feedbase plan:

- MLA Board requested in mid-2010 development of a comprehensive pastures and feedbase RDE investment plan;
- A review of Pastures Australia recommended a national pastures strategy be developed;
- Following development of the national beef and sheep RD&E strategies, PISC identified a deficiency in pastures and feedbase, recommending a national plan be developed.

The RMCiC pasture sub-committee commissioned the development of a feedbase investment plan (FIP) to determine researchable priorities in all southern agro ecological zones. Following the receipt of the FIP, the RMCiC initiated a process to provide greater clarity around the areas of R&D investment, the outcomes being sought, and the overall return on investment required. Three (of the five) R&D pillars are included in the current Feedbase R&D Plan:

- Pasture Breeding & Evaluation;
- Productive & Sustainable Pastures;
- Grazing Management & Production Systems.

The R&D pillars of Weeds/Biodiversity and Decision Tools, are being developed in a parallel process, but are not reported here. A former R&D pillar (Soils) has been merged into the Productive & Sustainable Pastures pillar in this Feedbase R&D Plan (the FR&DP). The FR&DP is based on the new model of collaborative engagement with the RMCiC agencies to ensure a focus on cross agency engagement of the best capabilities combined with collective development of the actual projects.

The development process has encompassed:

- A review of pasture improvement, agronomy & management and grazing systems, each producing a “narrative” outlining opportunities and challenges;
- Widespread consultation including producers, advisors and consultants, and researchers;
- A call for projects focussed on the 3 R&D pillars of Pasture Breeding & Evaluation, Productive & Sustainable Pastures, and Grazing Management & Production Systems.
- A workshop to review these projects that included a team of leading producers, MLA staff and technical specialists;
- The development of principles/philosophies to underpin the Feedbase Program – eg there will be a focus on participatory R&D in all themes as a key way to engage leading producers;
- Identifying some projects or project areas for immediate initiation, and others that require further development for a January 2012 start and yet others that require a major review and planning process and that might start projects in July 2012 – ie a staged investment process to grow into those areas that are being investigated with RMCiC partners.
- Benefit-cost analysis across each theme within the 3 R&D pillars

The feedbase portfolio has reached a stage of development where implementation must commence while recognising there is substantial project level development yet to occur. Further development is likely to identify emerging opportunities and so budget allocations may need to change and where warranted a case developed for increasing the proposed budget in feedbase R&D. That is, this report presents the base case to address the priority issues in feedbase R&D, and as development unfolds potentially a budget expansion will be required to accommodate high value projects that are identified and then collectively developed.

We are recommending a staged approach, with some projects that have reached a high level of collective agreement budgeted to begin in July 2011, with minimal further development. There is a second suite of projects that require more input – perhaps workshops, minor reviews, producer consultation, or the formation of extra linkages across agencies or agro-ecological zones – and these projects should be ready for final approval by December 2011. The final stage consists of project areas where major development is needed – perhaps a major science review, and certainly researcher and producer consultation, workshops etc – and the aim should be to have these projects ready for final approval by the end of June 2012.

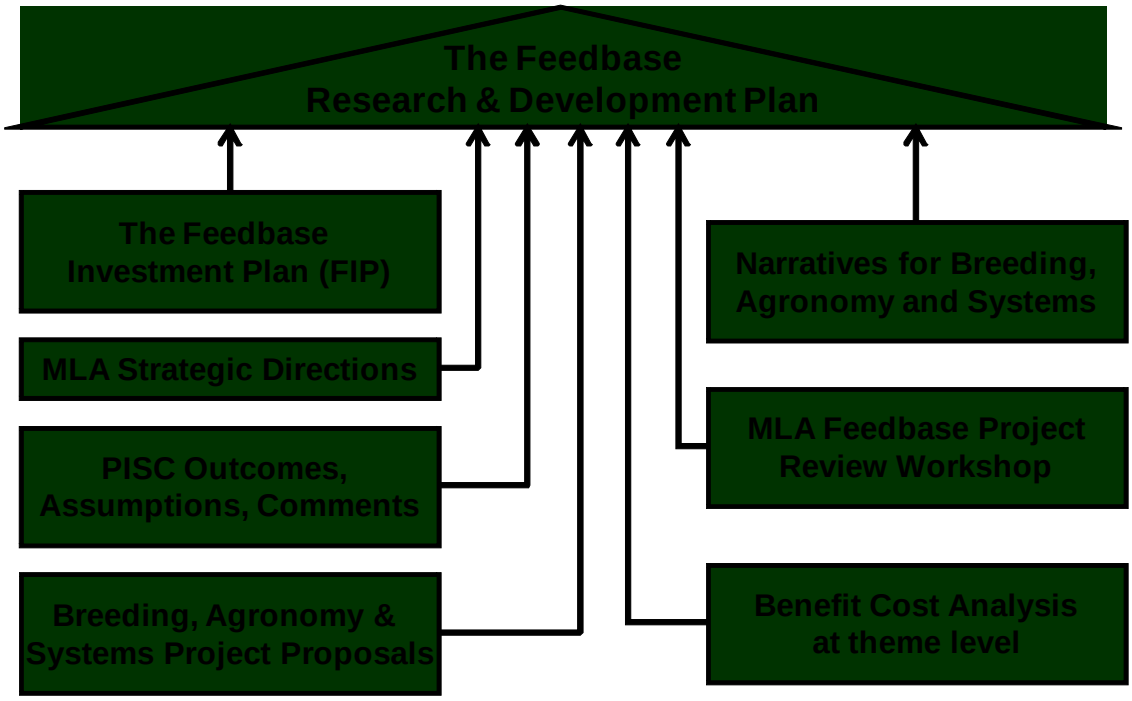
The overall outcome in 2020 is:

- Pasture improvement is adding $25m on-farm value per year by 2020
- Kg meat per ha rising at 2.5% pa, with no decline in sustainability indicators

The results from the BCA are positive across all the R&D pillars:

- Net Present Value of $105m over 30 years
- BCR of 7.12
- IRR of 8.9%

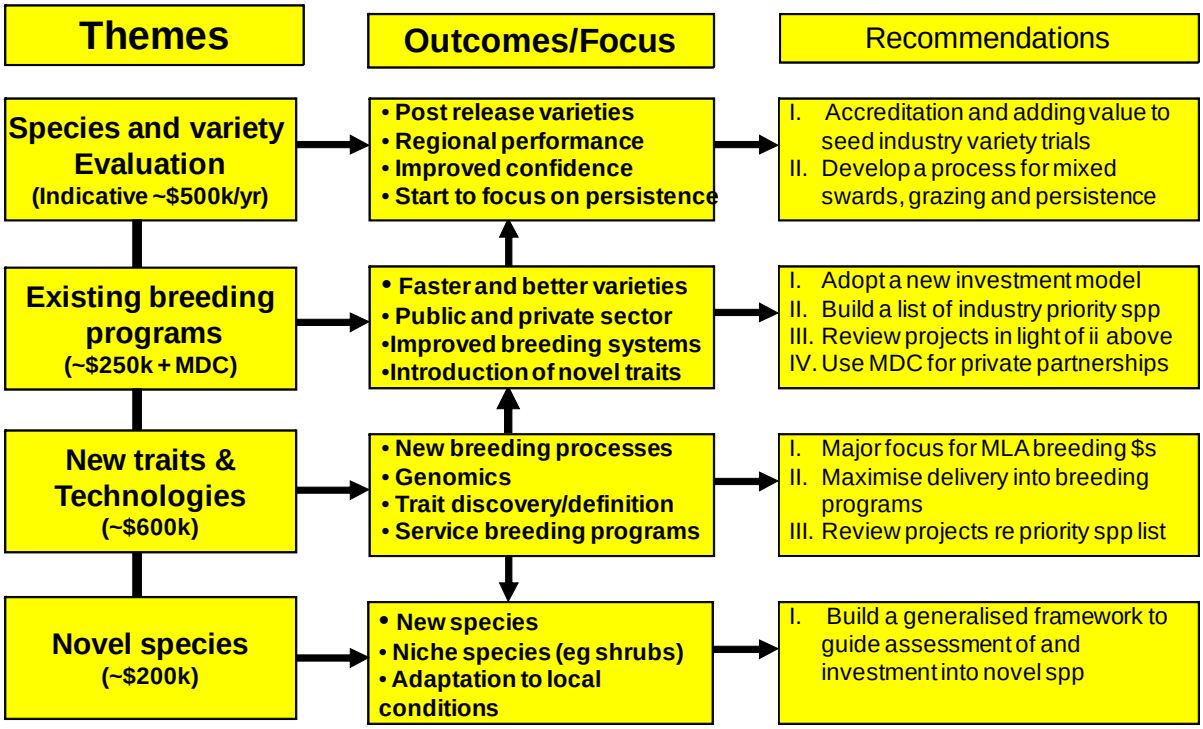
The inputs to this Feedbase R&D Plan are summarised in the figure below.



These inputs have been aggregated to determine the focal areas of effort in the three R&D pillars of Pasture Breeding & Evaluation; Productive & Sustainable Pastures; and Grazing Management & Production Systems. Each of these pillars is briefly summarised.

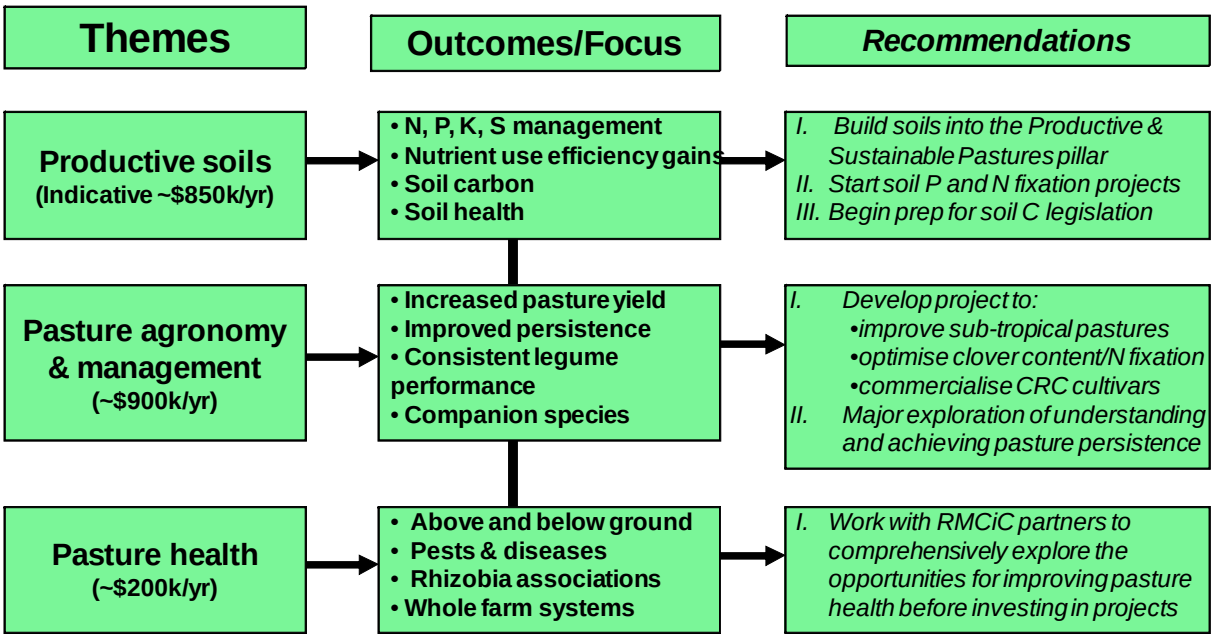
Pasture Breeding & Evaluation R&D Pillar

The overarching goal of this R&D pillar is to increase producer profit through delivery development of superior cultivars, making them available faster, and providing objective information on performance to build confidence to invest in pasture improvement. The outcome required is to have better (higher yield or quality, more persistent, better fit with animal system demands, etc) forage species and cultivars available to meat producers.



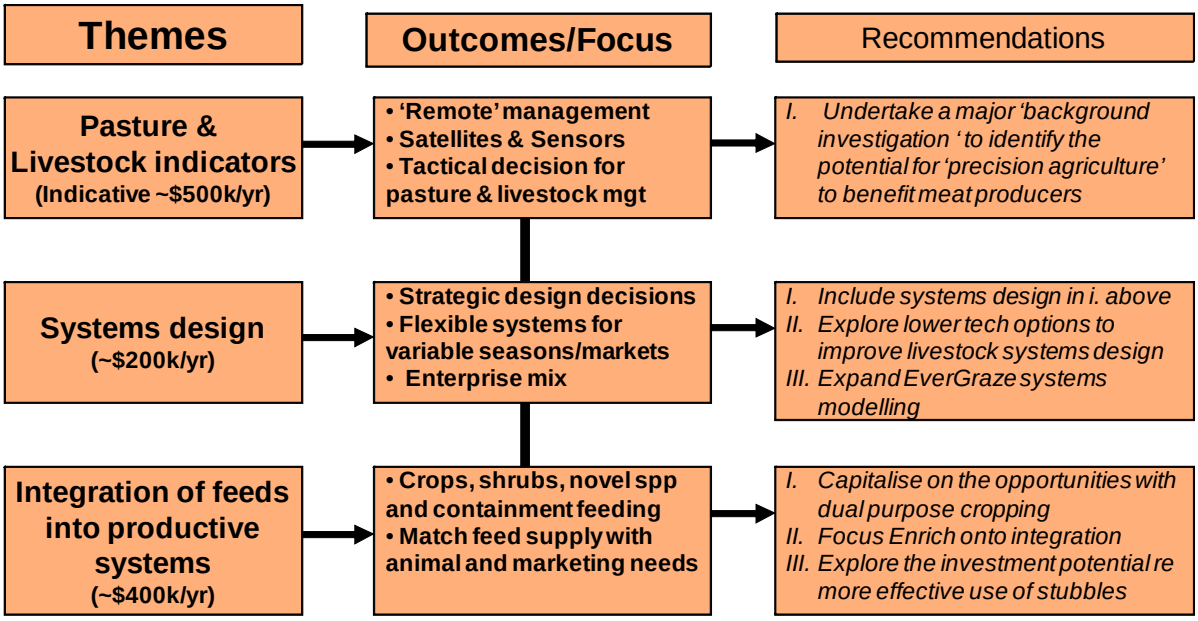
Productive & Sustainable Pastures R&D Pillar

The overarching goal of this R&D pillar is to increase pasture 'performance' and reduce costs of production per unit of forage, through the development of new tools and technologies to better manage the soils and the pasture feedbase for productivity and sustainability.



Grazing Management & Production Systems R&D Pillar

The overarching goal of this R&D pillar is to increase profit by increasing the margin between cost of production and sales revenue. The role of research and development in grazing management and production systems is to optimise stocking rates through better managing pasture utilisation in concert with enterprise flexibility and to fit these into a business management framework. These changes must improve labour efficiency, optimise pasture management for production and NRM outcomes, produce agricultural systems that are resilient to seasonal variation, manage risk and deliver products that meets market specifications and community expectations.



Budget Summary

The suggested budget in the figures above has arisen from the consultation process and represents only the MLA cash contribution – other partners will invest in particular projects and those budgets will be finalised as the projects are approved. As many of the projects in the portfolio are still under development and the investment opportunities yet to be finalised, the budget below is ~25% less than what is considered may be the longer term requirement to adequately fund the three focal pillars. The budget will be modified based on the development and emerging opportunities, and where warranted a case presented to increase the allocation to the feedbase portfolio.

R&D Pillars	Industry outcomes	Proposed MLA investment 2011-2016 $m	Proposed MLA investment 2011-12 $m
Pasture breeding & evaluation	Producers able to choose better varieties	6.68	1.16
Productive & sustainable pastures	Producers able to manage pastures better	9.35	1.74
Grazing management & production systems	Better animal production from pastures	4.45	0.91
Program governance, monitoring & evolution		2.05	0.41
Feedbase delivery		4.63	0.93
Totals		27.16	5.15

Contents

1 Background to the FR&DP

MLA (and MRC) has invested in a range of areas within the broad heading “pastures and feedbase” over the last 20 years. Since 2000, the overall investment has been at approximately $4m pa, spread across plant breeding, pasture establishment & recruitment, pasture agronomy, grazing & pasture management, production systems, soils, dryland salinity, nutrients, weeds (ecology & bio-control), biodiversity, rabbits, decision support tools, and included some limited strategic science (longer-term), applied (medium term) and implementation projects.

Across the portfolio, outcomes have included new knowledge in the multiple dimensions of the feedbase (soil, water, nutrient, pasture animal interaction), production & natural resource management, successful engagement and collaboration across the public and private sector, state and federal initiatives, established widespread producer networks (pastoral to high rainfall) and documented change of at least 10,000 producers.

However, recognising the common pasture interest yet fragmentation of many organisations, three initiatives converged in early 2010, seeking to develop a feedbase investment plan:

- MLA Board requested in mid-2010 development of a comprehensive pastures and feedbase RDE investment plan;
- A review of Pastures Australia recommended a national pastures strategy be developed;
- Following development of the national beef and sheep RD&E strategies, PISC identified a deficiency in pastures and feedbase, recommending a national plan be developed.

The need for a southern feedbase investment plan underpinning the national Lamb/Sheepmeat and Beef plans has been recognised and supported by the Red Meat Co-investment Committee (RMCiC). The RMCiC’s Economic Evaluation Modelling Group identified “Pastures” within the national strategies, as one of the highest priority and opportunity areas. Implementation of the national strategies has required a new “collective development” model. This new model is aimed at improving coordination and investment efficiency by addressing the research fragmentation in livestock production.

Accordingly, the over-arching aim in the development of this plan has been to provide greater clarity around the areas of work, strategic priorities of all the RMCiC partners, the outcomes being sought, and the overall return on investment required.

The RMCiC pasture sub-committee commissioned the consultation process and situation analysis to develop a feedbase investment plan (FIP – see Appendix A). The focus was to determine researchable priorities in all southern agro ecological zones. The approach taken to develop the FIP involved an industry survey followed by extensive consultation with key informants, representative of sectors and agro-ecological regions within the feedbase industry. Overall 576 responses were collected from the industry, including ~444 via a broad based survey, subsequent researcher, advisor organisational surveys and 130 in-depth interviews with producers, researchers, advisors. Barriers to adoption (of technologies that would increase meat production) were identified, then research opportunities to further increase the profitability and sustainability of red meat production.

2 Agro-Ecological zones and livestock distribution

(This section is drawn directly from the Feedbase Investment Plan – Shovelton et al 2011)

Throughout this Feedbase R&D Plan, the agro-ecological zones shown in Figure 1.

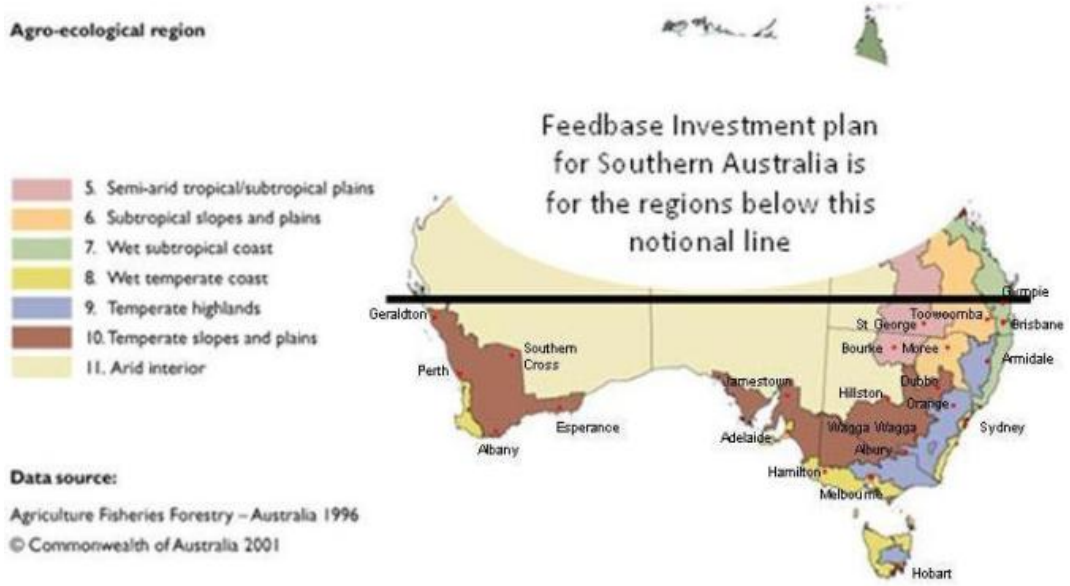


Figure 1: Agro-ecological regions of Southern Australia

In 2001 the area of 'Native & Self Sown' pastures across all agro-ecological regions totalled 28.61 million hectares. This grouping includes pasture in low input pastoral areas and some low productivity pastures in higher rainfall regions. In 2001 the 'Sown' pasture area was 21.88 million hectares. ABS ceased to collect sown pasture data after 2001.

The size of the beef cattle herd across all six agro-ecological regions declined from 10.17 million head in 2001 to 9.66 million head in 2009 (Fig. 2).

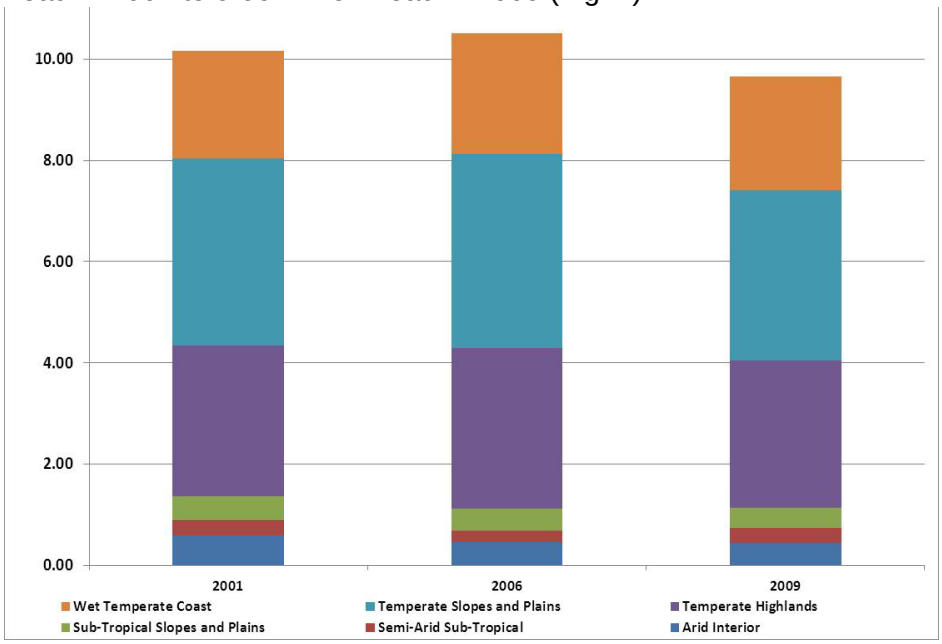


Figure 2: Beef cattle numbers (millions) by agro-ecological region in the years 2001, 2006 and 2009.

The reduction in the sheep flock was relatively greater with the total number of sheep and lambs falling from 101.46 million in 2001 to 68.48 million in 2009 (Fig. 3).

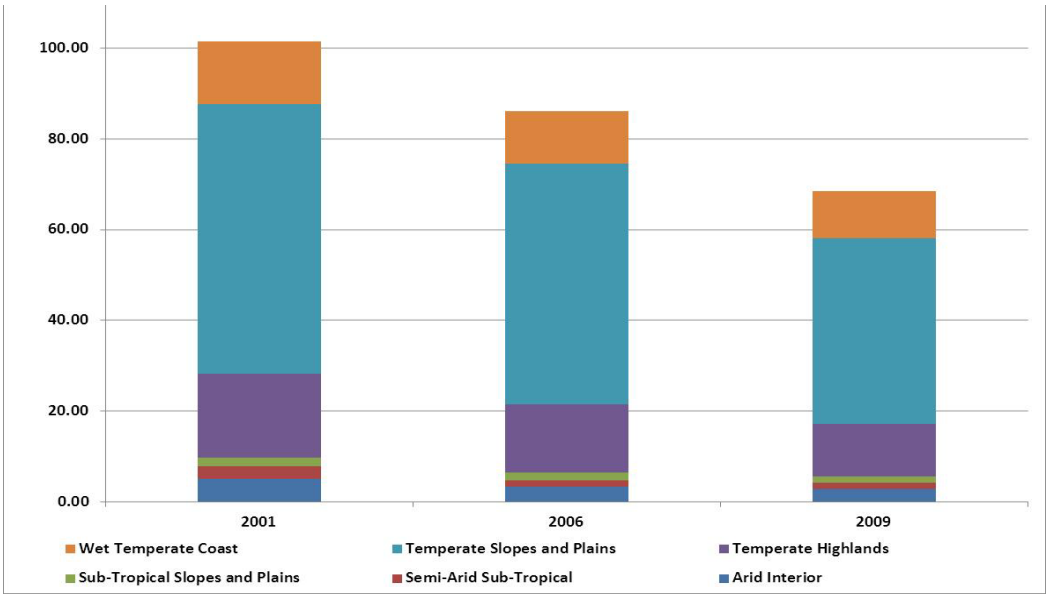


Figure 3: Sheep numbers (millions) by agro-ecological region in the years 2001, 2006 and 2009.

These changes, especially in the sheep flock reflect a combination of drought across all six regions, continuing low prices for wool, and a shift to cropping driven by grain prices. Prospects for the beef, sheep and grains industries within the regions and states of interest have been remarkably transformed due to the improved climatic conditions since the end of 2009.

The Australian Bureau of Agricultural and Resource Economics (ABARE) predicts that the growth in the number of beef cattle and sheep within the regions of interest will be 20.83 million DSE (dry sheep equivalents) by 2015. This equates to approximately 717,000 cattle and 5.08 million sheep.

3 Developing the Feedbase R&D Plan (FR&DP)

Following receipt of the FIP (Feedbase Investment Plan – see Appendix A), MLA acting as agent for the RMCiC instituted a multi-faceted approach that has resulted in this plan. Many of the steps described below overlapped in time, but with the following general sequence:

1. The framework for the feedbase program was determined and is presented in summary in Figure 4. Though shown as independent structures, the five R&D pillars will have strong cross linkages, linkages with other key areas (eg climate and NRM) and will be strongly connected to leading producers to ensure a focus on the whole system.

The inputs to the FR&DP are summarised in Figure 5.

2. It was determined that the FIP extension strategy was sufficiently detailed to submit to the MLA Board for approval. After Board rejection of some of the elements of the strategy, further development of the delivery strategy has been delayed until the R&D directions become clear. However, the target audience for the investments are the lead producers – those who are seeking information and want to make a change to their grazing & livestock business. Participatory research processes will be a feature of this investment plan.

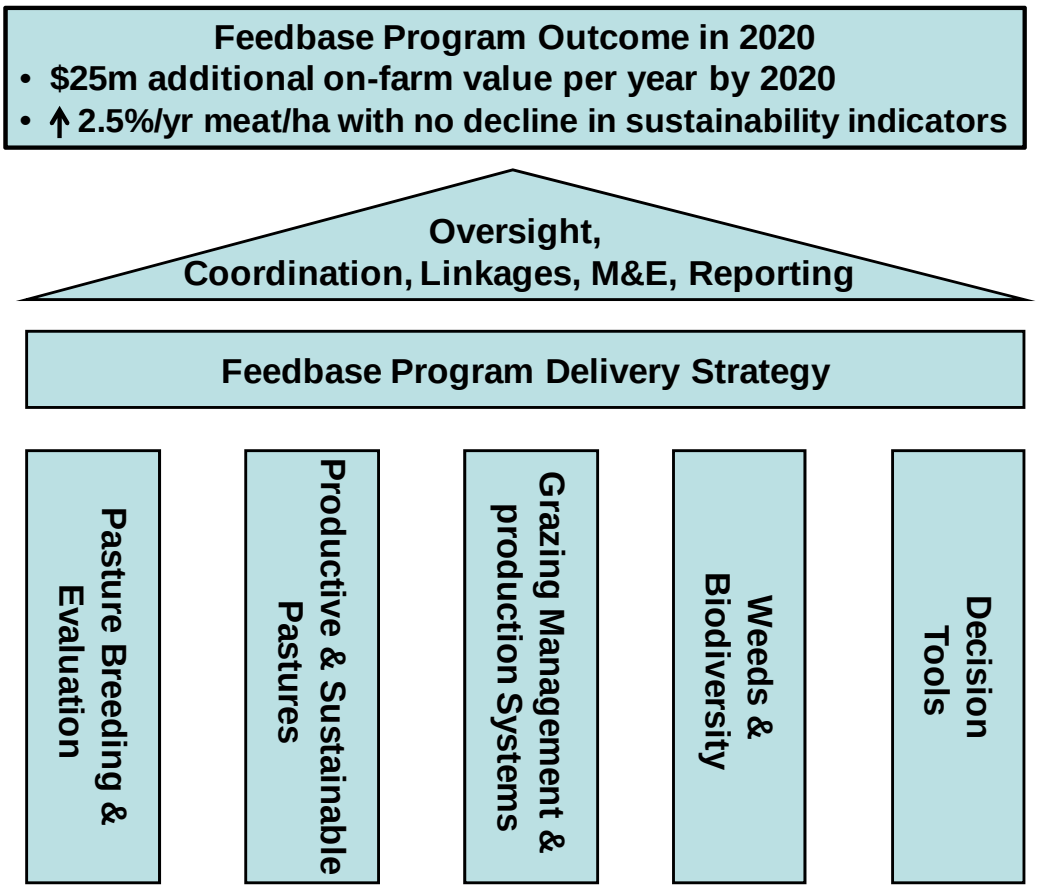


Figure 4. The five feedbase R&D pillars, a delivery strategy and a management/oversight process to deliver the 2020 outcome.

3. The feedbase program goal was set as adding $25m on-farm value per year by 2020, with kg meat per ha rising at 2.5% pa and with no decline in sustainability indicators. The R&D in the feedbase program was directed to target the top 20% of producers – loosely those who are already operating at a level that could be described as good industry practice.

4. While the FIP identified the key R&D priorities, there was insufficient detail in the FIP to move directly to commissioning projects. To build the next level of detail, MLA appointed a feedbase coordinator (Warren Mason) in late January 2011 to lead the of process creating the Feedbase R&D Plan. Of the 5 R&D pillars, only 3 were selected for inclusion in the FR&DP – weeds/biodiversity is being developed by a similar process running in parallel to the FR&DP, and it was decided to postpone the Decision Tools pillar until the projects in the other pillars had been clarified. The DSS theme is to provide an integration function across the FR&DP.

5. At the same time as the feedbase coordinator was appointed, MLA contracted a Development Coordinator to each of the 3 R&D pillars:
    - Kevin Smith for Pasture Breeding & Evaluation (PBE)
    - David Hudson for Productive & Sustainable Pastures (PSP)
    - Lewis Kahn for Grazing Management & Production Systems (GMPS)

   The role of the development coordinators was to:
    - Prepare a 'narrative' or evidence base to guide investment in the R&D pillar. The narrative is not a formal 'review of the literature', but rather a collation of what has been learnt from R&D, opportunities and producer experiences in this area over the last 10 years and therefore where the key investment opportunities lie.

[Narratives are attached - PBE as Appendix B, PSP as Appendix C and GMPS as Appendix D]

- Coordinate a call for project proposals within the R&D pillar, with the aim of developing a suite of projects that logically combine to achieve the outcomes identified in the FIP, across the key agro ecological zones.

[The process used for the call is outlined in Appendix E]

- Manage the selection of candidate projects and identify any gaps through a workshop process with leading producers and independent experts.

[Workshop reports attached – PBE, PSP and GMPS as Appendices F, G and H respectively]

- Assist the feedbase coordinator with the preparation of the FR&DP.

6. To ensure scientific and practical rigour, MLA convened an independent refereeing process for the narratives and review process for the proposals. A workshop was convened (March 29 & 30) with technical reviewers and 7 leading producers from southern Australian regions, to review the submitted project proposals.

7. The final inputs to the development of the FR&DP were from the RMCiC pasture sub-committee (see Appendix I), the MLA strategic directions (see Appendix J), and a cost benefit analysis, undertaken at the theme level (ie a level below the R&D pillars in Figure 4 but above the level of individual projects (see Appendix K). In addition, the RMCiC pasture sub-committee reviewed the draft of this plan and provided significant feedback as inputs to this approved draft.

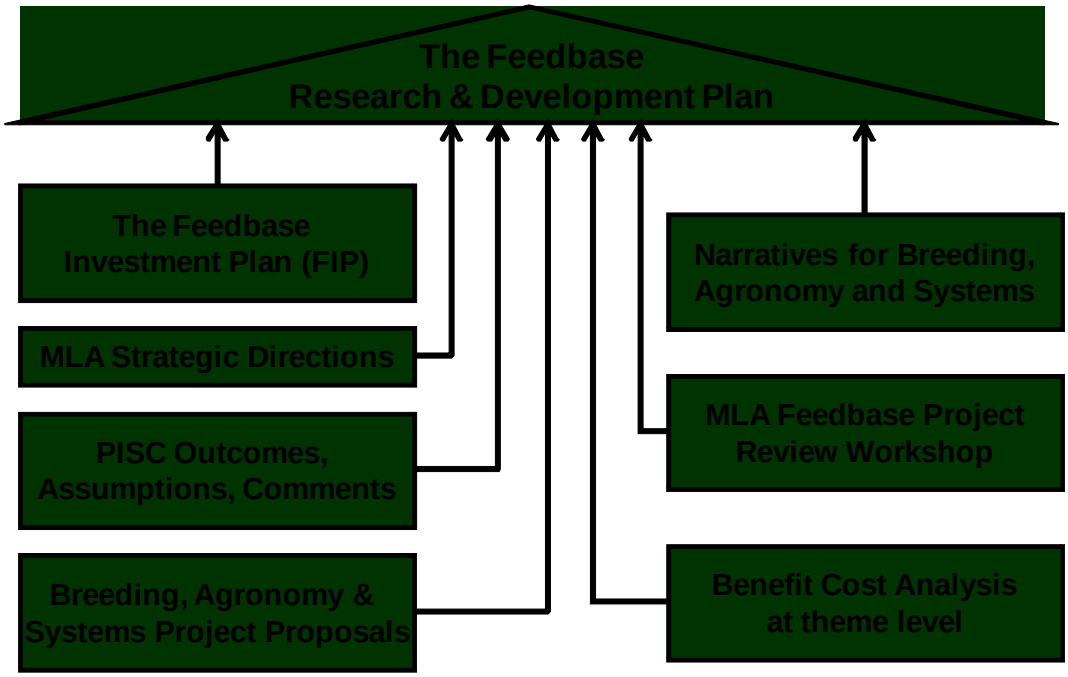


Figure 5. The feedbase R&D plan was created on the basis of multiple inputs.

4 The Principles/Philosophies underpinning the FR&DP

There are a set of principles/philosophies that underpinned the development of the FR&DP – understanding these will provide significant insights into the decisions that were made. These principles/philosophies have considerable overlap but collectively position the FR&DP:

- The FR&DP is based on a new model of collaborative engagement with the RMCiC agencies with a focus on cross agency engagement of the best capabilities and collective development of the actual projects.
- The R&D will be focussed on the needs of the leading 20% of producers, and these producers will be actively engaged at all levels, from project selection and implementation to program oversight and reviews of progress.
- There will be a focus on participatory R&D wherever possible in all themes as a key way to engage leading producers.
- Linking the R&D into the feedbase delivery strategy (under development) is a critical requirement for all projects.
- Resource use efficiency is a focus for all themes – this includes all financial, biophysical and human resources.
- Achieving the feedbase program goal (adding $25m on-farm value per year by 2020, with kg meat per ha rising at 2.5% pa and with no decline in sustainability indicators) will likely require a combination of improving production/profit/NRM outcomes as well as protecting existing gains from erosion via pests, diseases etc.
- Preference will be given to projects that demonstrate a sound/innovative approach; with collaboration across organisations and agro-ecological regions; with links to complementary areas of research; that incorporate ‘stretch’; and that contribute to positive outcomes for NRM, and for labour and for resource use efficiency. Both component and systems R&D will be undertaken.
- A major feature will be the search to maximise the multiple benefits that can be achieved from a single intervention, while understanding and managing the synergies and trade-offs. This includes the consideration of spatial issues – where things are done on farm can have a big impact on the quest for multiple benefits.
- The feedbase R&D program will undertake components work as well as enabling an understanding the ‘systems fit’ – the right animals grazing the right pastures and forage combinations to meet personal aspirations and market requirements.

5 Overview of the Feedbase R&D Plan

As outlined in Figure 4, the general framework for the FR&DP consists of 5 R&D pillars, a delivery strategy and a management/oversight structure. The Weeds/Biodiversity pillar and the delivery strategy are not discussed further in this plan. The Decision Tools and the proposed management/oversight structure are discussed below.

The research objectives/outcomes for each of the R&D pillars are presented in Figure 6, with the 3 R&D pillars that are included in this plan highlighted.

Though structured as a series of R&D pillars, these are not independent investment areas. Issues such as resource use efficiency, NRM, the quest for multiple benefits from each management intervention, and of course 'delivery' will act as 'themes' that run across all the R&D pillars.

Portfolio Goal
That the improvements in the feedbase envisaged in this plan will be adding $25m on-farm value per year by 2020, with kilograms of meat per hectare rising at 2.5% per annum. This involves better decision/better management of (if appropriate) better plants but with no decline in sustainability indicators. The proposed investment is $5-7.5m pa over 5 years.

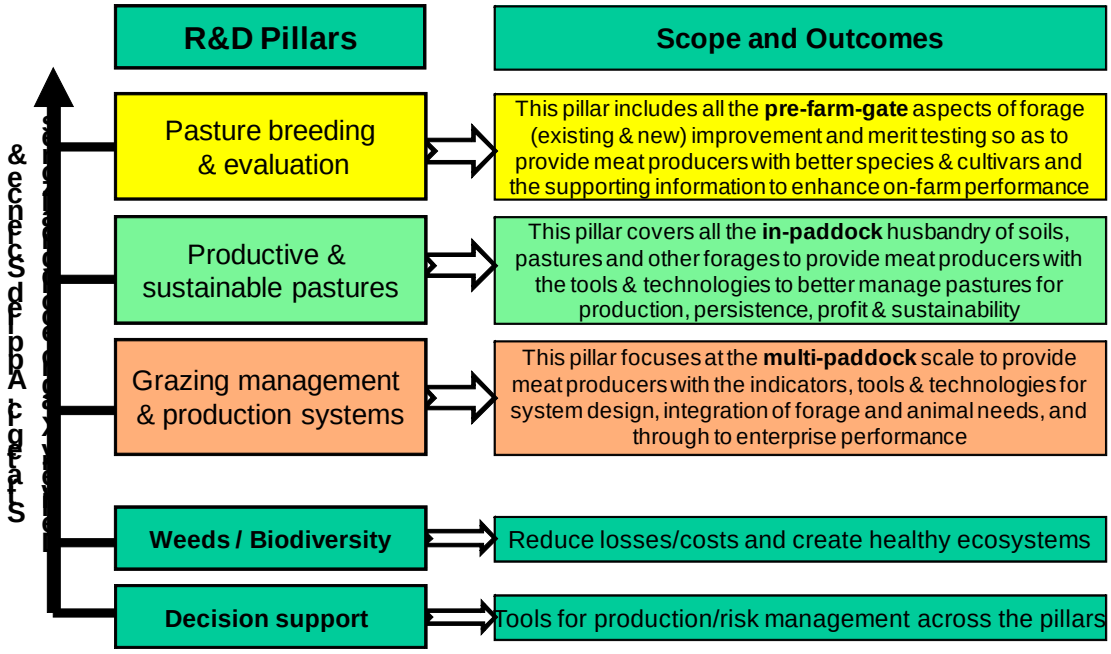


Figure 6. The research scope/outcomes for each of the 5 R&D pillars.

The soil, water and nutrient interactions will feature across the portfolio taking into account the implications on and off farm.

Pillar 1 - Pasture Breeding and Evaluation

The pasture breeding and evaluation process has been the subject of numerous reviews in recent years – as well as during the FIP consultation process. What these reports lack is an analysis of how well current pasture cultivars fit the requirements of leading producers who are the key target for this Feedbase R&D Plan. There is no 'industry agreed' priorities at either the species or the traits level on which to base industry investment decisions.
The meat industry has been moving towards the 'investment decision process' used in the grains industry (see Figure 7) where the private sector is primarily responsible for near market and

commercial activities, while the industry and public sector invest in generic technologies and areas of market failure.

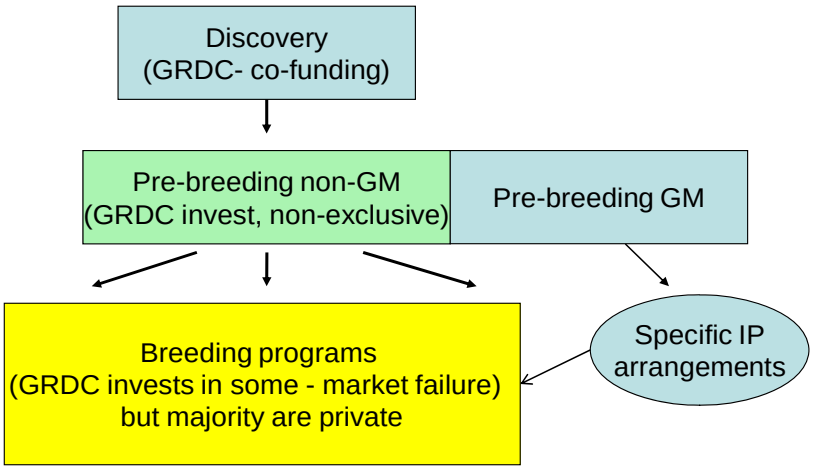


Figure 7. The grains industry model that has been implemented by PISC agencies. In this model industry levies (and PISC agency investments) are concentrated on the discovery and pre-breeding stages of the R&D pipeline

The overarching goal of this R&D pillar is to increase producer profit through delivery/development of superior cultivars, making them available faster, and providing objective information on performance to build confidence to invest in pastures. The outcome required is to have better (higher yield or quality, more persistent, better fit with animal system demands, etc) forage species and cultivars available to meat producers.

The FIP consultation process (FIP - see Appendix A) identified the key research deliverables for the *Pasture breeding & evaluation* pillar and these deliverables contain the key components of:

1. Uniform and independent genetic evaluation (including persistence) and demonstration of pastures species and varieties.
2. Improvement in the base pasture traits identified as important to meat producers – viz persistence, forage production quality and timeliness, P efficiency, seedling vigour and animal health outcomes;
   - Pasture legumes with the additional features of tolerance to low pH, performance in mixed swards and adapted to shorter/more variable seasons and sub-tropical regions;
   - Pasture grasses with the additional features of reduced toxicity, better aluminium tolerance and adaptation to variable seasons and sub-tropical regions.
3. Tools and processes to assist meat producers and service providers access and utilise the most suitable pasture genetics.

These deliverables are applicable to all agro-ecological regions other than the arid interior.

Some of the key challenges for this R&D pillar include:

→ Adapting the grains industry model to suit the diversity of the forage industry;

→ Defining the industry priorities for both species/traits and production/NRM;

→ Clear definition of where market failure exists in breeding programs;

→ Development of a national variety evaluation program that both meets the objective information needs of leading producers and enables efficiency in pasture research;

→ Bringing the most advanced genetic technologies (eg molecular biology; genomics[1]) to focus on genetic gains in forage species of importance to Australian meat producers;

→ Building the case for pasture improvement in those areas where commercial returns are available, and thereby boosting the rate of pasture re-sowing.

A summary of the investment recommendations for the Pasture Breeding & Evaluation pillar is presented in Figure 8. For a more detailed account, see section 8.

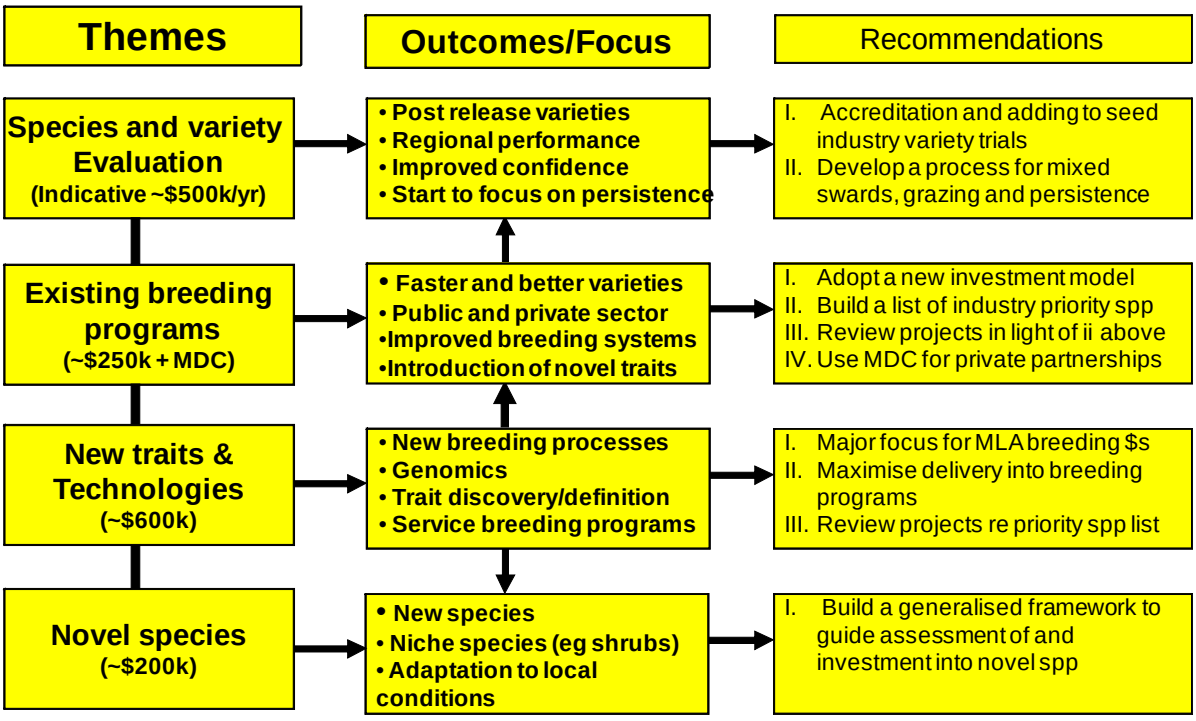


Figure 8. Summary of the Pasture Breeding and Evaluation pillar.

Pillar 2 – Productive and Sustainable Pastures

Over the last decade, investment in pasture agronomy and management research has been directed towards activities such as fertilizer and weed management, pasture establishment and to a limited extent the control of pests such as red-legged earth mite and lucerne flea. The common objective of these programs was to develop the principles, tools and indicators for improving the profitability and sustainability of grazing systems across the agro-ecological diversity of southern Australia.

In a similar vein, the overarching goal of this R&D pillar is to increase pasture 'performance' and reduce costs of production per unit of forage, through the development of new tools and technologies to better manage the pasture feedbase for productivity and NRM outcomes.

The FIP consultation (see Appendix A) identified the key researchable deliverables for the *Productive & Sustainable Pastures* pillar as including:

1. Pasture Health – Improved pasture nutrition through a combination of increased soil fertility, and/or fertiliser precision, and/or soil biological processes

[1] In this report 'genomics' includes genetic mapping and the study of the entire DNA sequence (or genome). In contrast, investigation of the role(s) of single genes falls under the heading of molecular biology or genetics.

2. Pasture Composition - Increased content of desirable species and increased consistency of legumes in pastures
3. Pasture Maintenance - Reduced incidence/ impact from abiotic and biotic stresses in pastures
4. Pasture Management - Pasture management tactics that improve pasture persistence, productivity and quality and that address feed gaps and seasonal variability
5. Productive Pastures - Tools and processes to assist meat producers and service providers increase pasture performance.

As this pillar has been expanded to include 'Soils' (originally an independent pillar), the focus on soil health, soil carbon and overall sustainability has increased.

Deliverable 1 (especially the focus on fertilisers) is not applicable in the arid interior. Apart from that exception, all the deliverables have application in all the target agro-ecological regions.

Some of the key challenges for the Productive & Sustainable Pastures R&D pillar include:

→ Merging the 'soils' pillar into Productive & Sustainable Pastures;

→ In doing so, not losing a strong focus on pasture agronomy and management;

→ Recognising that other nutrients (eg K and S) and other soil based challenges (eg soil acidity) are important regionally and/or nationally;

→ Understanding (and focusing on) the particular challenges being faced by 'leading producers' who are the target for this R&D pillar;

→ Providing coverage of improved and unimproved pastures;

→ Forming a coherent and focussed response to the Phosphorus review;

→ Ensuring the right balance between production and NRM goals;

→ Keeping pace with the emerging focus on soil carbon via the Carbon Farming Initiative and feedbase solutions for a hotter, drier and more variable climate;

→ Developing a leading edge program of work around the highly important but experimentally difficult issue of 'pasture persistence'.

A summary of the investment recommendations for the Productive & Sustainable Pastures R&D pillar is presented in Figure 9. For a more detailed account, see section 9.

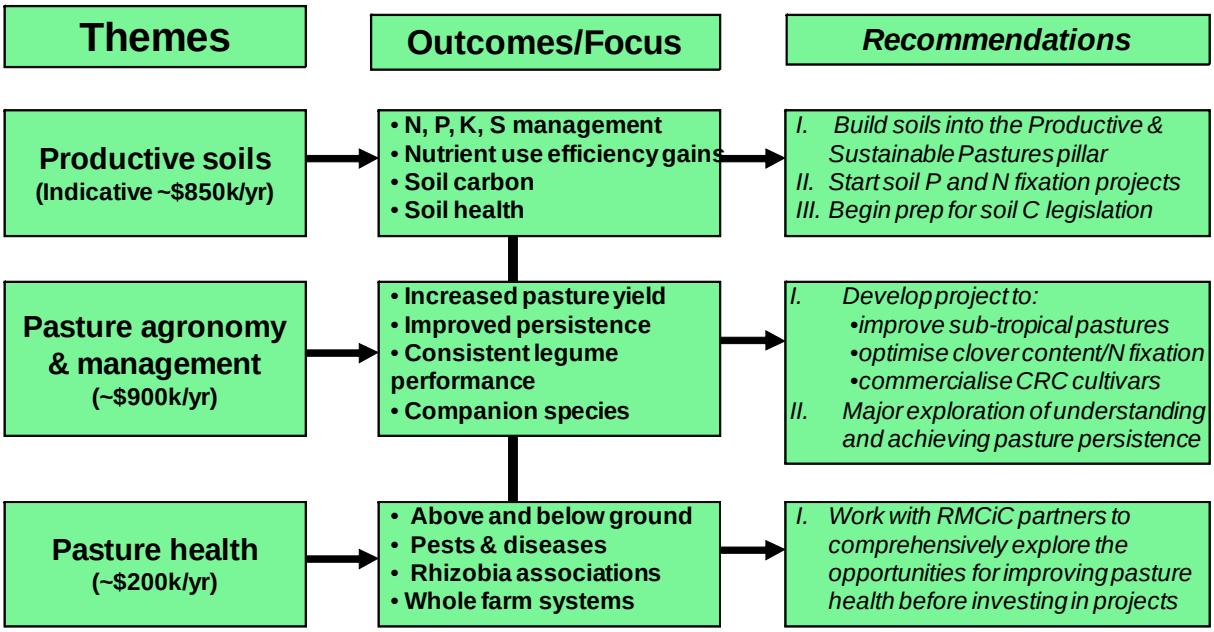


Figure 9. Summary of the Productive and Sustainable Pastures pillar.

Pillar 3 – Grazing Management and Production Systems

Since the mid 1990s, there has been significant investment and a large advance in understanding of the role that grazing management plays in pasture and livestock performance. The identification of leading producers as the target market for this round of R&D brings into focus the need for research to stretch beyond the known science and to ultimately integrate both feedbase and livestock needs.

The overarching goal of this R&D pillar is to increase profit by increasing the margin between cost of production and sales revenue. The role of research and development in grazing management and production systems is to optimise stocking rates through better managing pasture utilisation in concert with enterprise flexibility and to fit these into a business management framework. These changes must improve labour efficiency, optimise pasture management for production and NRM outcomes, produce agricultural systems that are resilient to seasonal variation, manage risk and enables product that meets market specifications and community expectations.

The FIP consultation (see Appendix A) identified the key researchable deliverables for the *Grazing Management and Production Systems* pillar and these deliverables contain the key components of:

1. Grazing rotation indicators and trigger points for matching stocking rates and pasture utilisation goals across different systems and regions to increase profit and deliver NRM benefits.
2. Evaluation of the impact of grazing strategies and pasture utilisation on livestock performance, risk, profit and sustainability
3. Systems that integrate livestock, forages (pastures, forage crops, legume break crops) and cropping enterprises to increase business profit and reduce business risks and NRM impacts
4. Evaluation of the strategic role of fodder conservation and containment feeding to improve feedbase and animal performance and to reduce soil and pasture degradation
5. Tools and processes to assist meat producers and service providers improve grazing management/systems.

Deliverables 1, 2 and 5 are applicable to all agro-ecological regions including the arid interior. Deliverables 3 and 4 are more specific to the mixed farming zones – Temperate Slopes & Plains, Sub-Tropical Slopes & Plains, and Semi-Arid Tropical & Sub-Tropical Plains

There is a need for collection (including remote collection) and interpretation of empirical data concerning pasture performance, the mechanics of grazing decisions, animal behaviour and performance and its use in optimising farm business performance.

Some of the key challenges for the Grazing Management & Production Systems R&D pillar include:

- → What are the particular grazing management and systems challenges being faced by 'leading producers' who are the target for this R&D pillar;
- → What is the right balance for the pillar between high tech (eg satellite monitoring) and lower tech, simpler solutions and between science push and producer demand;
- → What is the 'right' balance between work on high vs low input systems;
- → Ensuring systems design and monitoring incorporate both production and sustainability indicators;
- → Systems research is very challenging for researchers because of the multiple requirements - we want to maintain sown pastures, increase utilisation, better match supply and demand, meet animal production/turnoff targets, integrate with crops, integrate with shrubs etc;

A summary of the investment recommendations for the Grazing Management & Production Systems R&D pillar is presented in Figure 10. For a more detailed account, see section 10.

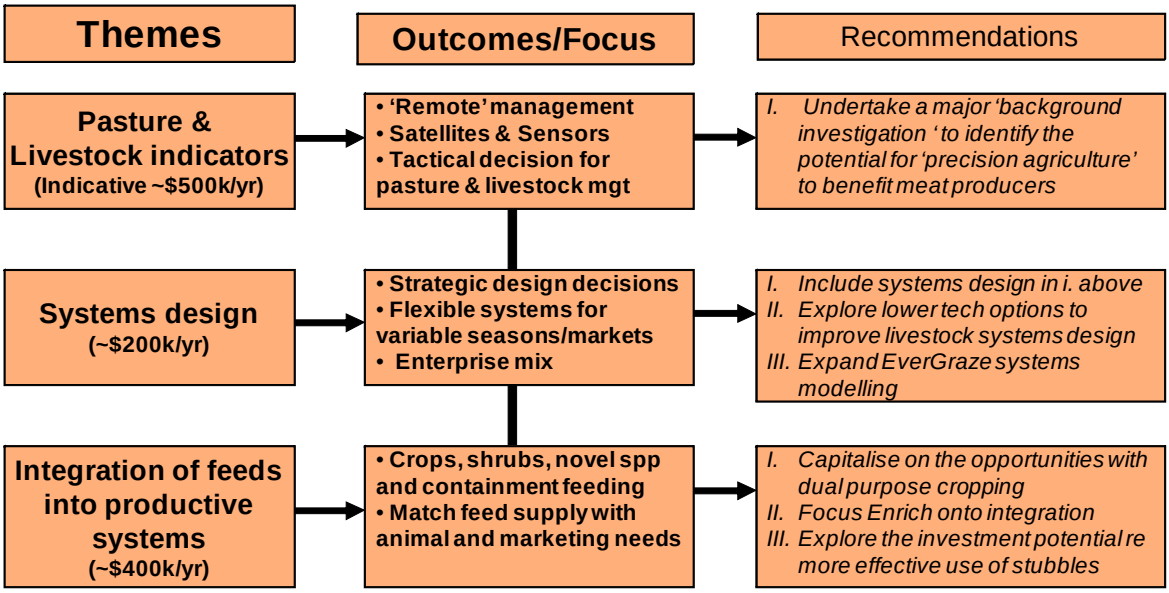


Figure 10. Summary of the Grazing Management and Production Systems pillar.

6 Feedbase Program Management & Oversight

Following development of the national beef and sheep RD&E strategies, and the deficiency in pastures and feedbase R&D identified by the PISC process, the traditional R&D model based on MLA selecting projects from agency bids has to change. The future model (though not yet clearly defined and care must be taken not to throw out the baby with the bathwater) will feature:

- Rolling investment planning with producers involved in planning, implementation and review.
- Establishing processes to address researcher fragmentation and reduce unnecessary competition between agencies while maintaining a high level of science quality and capability. Collective review and development is required.
- Overall portfolio management group with producer representation
    - Core job to ensure across program links
    - Logically aligned with the end goal
    - Develop delivery initiatives.
- Each pillar will have an advisory group with producers and agencies
    - Core job to ensure across theme links
    - Logically aligned with the pillar aims
    - This group is to meet annually with the research teams for ideas generation and cross theme interactions
    - Develop delivery initiatives within the pillar that align with those at a national level.

Major investments will include pre and post experimental modelling:

- new investments are to ensure stretch based on pre-experimental modelling
- post research modelling is to then propose next opportunity
- modelling is to contribute to *ex- ante* and *ex-post* BCA.

Monitoring & Evaluation:

- Every 2 years projects underway will be reviewed by a TTAG group (external scientist, producer, consultant). This group could work across pillars providing recommendation to the Pillar and overall management group
- All projects will develop their logical framework (linking activities to expected outputs and outcomes), and report against annual operational plans
- Evaluation processes (outside project agreements) will be based on a uniform process
- Given the focus on leading producers, a baseline survey/investigation is needed against which to assess practice change.

Communications

- Developed by the Management Committee
- Researcher forums – a technology sharing forum is to be developed to enable the research teams to interact
- Every 2 years a broad based producer survey will be conducted to solicit industry needs
- Pathway develop to update existing program material (MBfP, MMS) with research output.

Ideas generation

- Process to be developed where ideas are routinely proposed
- An open call will only be made on targeted issues to address a known gap or problem.

7 Feedbase R&D Benefit Cost Analysis

Benefit:cost analyses were undertaken by Michael Clarke of AgEconPlus Pty Ltd. The full BCA analysis is presented as Appendix K with a summary below in Table 1.

The BCA's were prepared to identify high priority/high impact MLA investments within three of the proposed Feedbase Programs:

- Pasture breeding and evaluation
- Grazing management & production systems
- Agronomy and management (now Productive & Sustainable Pastures)

- The BCA is calculated for benefits over 30 years
- Adoption is not assumed to commence until 15 years after start of the research
- Discount rate used is 7%
- Adoption is restricted to the 20% leading producers who are assumed to manage 40% of the ha available
- Adoption within this group takes 3 years from start of adoption*

In summary, the results are:

- Net Present Value of $105m over 30 years
- BCR of 7.12
- IRR of 8.9%
- Additional environmental and social benefits are expected but have not been included.

Table 1. The BCA summary for the 3 R&D pillars included in this Feedbase R&D Plan.

Theme	PV Benefits ($'million)	PV Costs ($'million)	NPV ($'million)	BCR	IRR (%)	Enviro	Social
1. Pasture Breeding and Evaluation							
1.1 Pasture Species Evaluation	9.05	1.49	**7.56**	6.06	7.8%	√	Nil
1.2 Existing and active breeding programs	13.54	0.98	**12.56**	13.86	11.9%	√	Nil
1.3 New and novel species	4.38	0.46	**3.92**	9.53	9.2%	√√	Nil
1.4 Traits and new technologies	9.49	2.82	**6.67**	3.37	4.4%	Nil	Nil
2. Grazing Management & Production Systems							
2.1 Grazing and animal indicators	10.22	2.59	**7.64**	3.95	6.6%	√√	√√
2.2 Interactions of crops, shrubs, novel perennials	13.93	1.15	**12.78**	12.12	13.7%	√√	√√
2.3 Containment feeding and fodder conservation	13.93	0.86	**13.07**	16.16	15.5%	√√	Nil
2.4 Strategic livestock system design	11.89	1.15	**10.74**	10.34	12.4%	√√	√√
3. Productive & Sustainable Pastures							
3.1 Nutrient balance	13.85	1.95	**11.90**	7.09	10.6%	√√	Nil
3.2 Re-estab & improve productive capacity of feedbase	12.27	1.90	**10.37**	6.47	9.4%	√	Nil
3.3 Pasture health, maintenance and productivity	10.24	1.90	**8.34**	5.40	8.0%	√	Nil

8 The Pasture Breeding & Evaluation Pillar in Detail

An overview summary of the Pasture Breeding & Evaluation R&D pillar has been presented in Section 5 of this report.

The overarching goal of this R&D pillar is to increase producer profit through delivery development of superior cultivars, making them available faster, and providing objective information on performance to build confidence to invest in pastures. The outcome required is to have better (higher yield or quality, more persistent, better fit with animal system demands, etc) forage species and cultivars available to meat producers. This pillar is focussed on all agro-ecological regions other than the arid interior.

The challenges for this R&D pillar include:

- → Adapting the grains industry model to suit the diversity of the forage industry;
- → Building/maintaining the public:private partnerships that are essential for the model to work over the longer term and defining the role of the MLA Donor Company in pasture breeding;
- → Keeping continuity as the different steps are a continuum needed to bring cultivars successfully to market;
- → Defining the industry priorities for both species/traits and production/NRM outcomes;
- → Clear definition of where market failure exists in breeding programs;
- → Development of a national variety evaluation program that both meets the objective information needs of leading producers and enable efficiency in pasture research;
- → Ensuring the evaluation process recognises that while relative merit of varieties is important, the real issue is relative suitability for the functional context/requirement;
- → Bringing the most advanced genetic technologies (eg GM; genomics) to focus on genetic gains in forage species of importance to Australian meat producers;
- → Finding the right balance between the high risk/high reward possibilities associated with biotechnology and niche species, and the on-going investment into conventional breeding in the major species;
- → Building the case for pasture improvement in those areas where commercial returns are available, and thereby boosting the rate of pasture re-sowing.

There are four ‘themes’ in the PBE pillar, and these themes are outlined in detail in Tables 2, 3, 4 and 5. For each theme table there is a desired outcome, key assumptions, recommendations/immediate actions, and the supporting rationale. The four themes are:

1. Species and cultivar evaluation (Table 2);
2. Species with existing public or private sector breeding programs (Table3);
3. New traits & breeding technologies (Table 4); and
4. Novel species (Table 5).

Table 2. Summary information (scope, outcomes, assumptions, etc) and rationale for the recommendations made for the ***species and variety evaluation*** theme

R&D Pillar	**Pasture Breeding and Evaluation**
Theme 1	**Species and Variety Evaluation**
Scope	*This theme covers projects that seek to evaluate forage cultivars, species or technologies for adaptation and/or performance in Australian environments or production systems with a focus on those regions where sown pastures are a major forage source for meat production.*
Outcome	*Australian meat producers are able to increase productivity and profitability through making better informed pasture species and variety choices based on robust and accurate description of relative performance and degree of 'fit for purpose'.*
Key Assumptions	- *Making the optimal choices of species and varieties will increase pasture production/quality and increase meat production per ha – currently, the information is not available to assist meat producers make these optimal choices;* - *With current information sources many species/variety selections are unsuitable and many more selections are sub-optimal for location or the on-farm purpose;* - *Improved confidence in pasture performance (eg performance under grazing and in mixed swards) will stimulate producer investment in re-sowing;* - *Leading producers are more likely to be re-sowing pastures and are therefore most likely to gain from objective information on species and variety performance;* - *A network of 'performance sites' can be used as a node for delivery of related information and provide objective data on breeding lines as well as released varieties*
Recommend-ations	1. *That MLA continues the process begun by Pastures Australia to provide meat industry investment into a "Auditing and Accreditation" framework to guide variety testing trials undertaken by the commercial seed companies. Opportunities to co-fund additional relevant measures, including forage quality testing (NIR) and animal production modelling should be explored with seed companies.* ***Action*** *– Contract the Auditing and Accreditation & EBV business plan implementation*
	2. *That MLA explores alternative processes to provide information on mixed sward performance, pasture persistence, and animal performance. Instead of costly demonstration or research trials, perhaps this might be based on the Wikipedia model of aggregating large amounts of lower quality data into reliable information.* ***Action*** *– Contract a scoping study on alternative processes to provide information on mixed sward performance, pasture persistence, and animal performance*
	3. *That MLA make an indicative allocation of $500k per year for projects in this theme*
Building on the theme	*This theme needs to develop through overt linkages with theme 2 (existing breeding programs) and with grazing management and agronomy projects. A network of sites can provide an improved basis for selection across regions and provide common infrastructure to defray breeding program costs. Centralised data collection and analysis should also be developed to provide species x region evaluation. Related research (eg P efficiency, water use) could utilise this network rather than establishing separate sites. Web delivery of the analysed data needs development, linked to output from animal production models.*

	The end result needs to be a much stronger integration of pasture variety evaluation with grazing management and on-farm knowledge of pasture variety and species performance.

Comments and rationale behind the recommendations

- The FIP consultation identified that one of the barriers to adoption of new technology was concern that the returns would not outweigh the costs and that producers would like to have greater confidence in local performance of pastures. Pasture seed companies each undertake regional testing of their own and competitor's lines, however producer confidence in the data presented from these trials is low because they provide none of the information listed above and are not seen as independent.
- Pastures Australia has piloted a variety testing program cross 3 sites with the support of seven seed companies. This project has allowed formation of an "Auditing and Accreditation" program to be developed with the support of seed companies and the Australian Seed Federation. The main elements include development of protocols for trials, analysis and reporting; accreditation of site managers, trial designs, data collection and QA checking; and web based management of trials and collection of data.

  This process accepts the reality that seed companies will undertake their own trials but that some (limited) collaboration can be achieved around the collective process. This should be continued, and MLA should explore the potential to add value to the seed industry trials by co-funding some forage quality testing of material from these cutting trials. Grazing and measurement of animal performance is not possible, but forage quality provides information that could be used to model some aspects of animal performance.

  If there are significant agro-ecological regions where seed company trials are not undertaken, there might be a case for MLA/local agencies and the private sector to intigate 'regional adaptation trials'.

- The highly successful, variety testing program undertaken by public and private providers in the grains industry is often held up as a model the 'pasture' industry could follow. Like grain-growers, livestock producers need to make informed choice regarding varieties that suit their required purpose. However, the grains model must be varied for meat producers. A livestock industry model must have longevity, and additional traits being evaluated, and incorporated into livestock production models. This information should be a coupled process (see below) to capture and communicate information on performance in mixed swards, performance under different grazing managements, persistence over relatively long times, animal performance (as opposed to simply yield) and economic analysis.
- Producers are asking for 'farm scale, long time-line performance information' about pasture species and varieties. It is virtually impossible to collect this information from research trials; it is exceedingly expensive because of the scale and time required, and over such time scales, it is the on-site management that has the greatest impact, not the particular pasture variety. On the other hand, individual producers are 'conducting' these paddock/farm scale, long term trials all the time simply by sowing and managing their pastures. A process should be established to capture producer experiences so their 'data' on persistence and mixed sward performance can assist other producers make more informed pasture choices

- MLA has a number of options for variety trials, including;
  i. they can be funded by MLA (there is little co-investment opportunity from the public sector) to ensure independence but the cost for MLA would be very high;
  ii. they can be funded by the seed companies but with MLA investment into QA and auditing as per the Pastures Australia model;
  iii. independent trials are funded by MLA in combination with seed company network of trials that are participating in a QA program. If MLA selects this option, then the project

assessment workshop has some recommendations (see Appendix F) and a preferred project;

iv. providing funding for groups in the key agro-ecological zones to undertake variety trials in addition to their other R&D.

We are recommending MLA develops a strategy that includes elements of options ii, iii and iv but with a primary focus on oversight for seed industry trials, and with the establishment of new sites only as last resort. New ways of supporting/assisting meat producers "*to increase productivity and profitability through making informed pasture species and variety choices"* need to be explored. One possibility is to consider ways to stimulate the generation, collection, aggregation and sharing of information from farmers who have sown particular species or varieties of interest. This data is widespread, but each 'data point' has much lower reliability than a formal research trial.

It may not be an appropriate analogy, but Wikipedia (the international, on-line encyclopaedia) operates this way – it builds up information from informal sources rather than doing 'research'. Using low quality data points (anyone can contribute), Wikipedia has built a reputation as a very reliable place to start almost any 'investigation'. By this process it has more or less totally replaced Encyclopaedia Britannica which was of course based on using only 'high quality' data points.

Table 3. Summary information (scope, outcomes, assumptions, etc) and rationale for the recommendations made for the ***species with existing breeding programs*** theme

R&D Pillar	**Pasture Breeding and Evaluation**
Theme 2	**Species with existing public or private sector breeding programs**
Scope	*This theme covers species that have existing breeding programs in the private or public sector - the species may either have broad usage (such as perennial ryegrass or lucerne) or be more focussed on specific environments or production systems (eg red clover, chicory).*
Outcome	*Australian meat producers are able to increase productivity and profitability through the more rapid breeding of cultivars and the incorporation of novel traits into these cultivars.*
Key Assumptions	- *Currently available local cultivars are sub-optimal for Australian conditions;* - *Without co-investment, pasture breeding in multinational seed companies will not focus sufficiently on the key traits important to Australian meat producers;* - *Industry co-investment in pasture breeding can result in better (more productive, higher quality, better match with animal needs, reduced costs per kg of meat produced) cultivars for Australian conditions or can hasten their market availability;* - *Rates of re-sowing will increase if better cultivars are available to increase returns;* - *Improved confidence in pasture performance will stimulate producer investment, and justify seed company investment;* - *whilst pasture production/quality are key areas to pursue, how it is utilised becomes a key factor and directly links into the other R&D pillars;* - *Market failure can be demonstrated to justify investment in plant breeding.*
Recommend-ations	*4. That MLA adopts the investment model that focuses industry and public sector investments towards pre-breeding (see theme 3) and evaluation/extension (see theme 1).*
	5. As a joint venture with theme 3 (traits and technologies) MLA should build industry support around a list of priority species and priority traits for those species. This builds on the 1000 Minds project and the Southern Feedbase Audit. In combination with the market failure assessment, this will inform future investment in breeding programs. ***Action** – Build industry support for the breeding objectives from 1000 minds project*
	6. That most investments into public - private sector breeding programs utilise the MLA Donor Company funding model, though such projects must be assessed against the priority species and traits list recommended above. ***Action** – Review the recommended projects following the outcomes of recommendation 5*
	7. That the projects submitted for this theme be re-assessed in the light of the outcomes of recommendation 5 above. ***Action** – Use the breeding objectives to re-assess project proposals for MLA investment*
	8. That (in line with the workshop recommendations, see Appendix F) MLA allocates an indicative annual budget of $250,000 for this theme in addition to MDC investments.
Building on the theme	*Forage breeding is increasingly international. A key role of MLA investment is to keep a focus on the needs of the Australian meat industry, either through ensuring that locally important traits/technologies are available for incorporation into*

	breeding programs, or through the support of breeding activities for important species/environments not serviced by the commercial sector. There are examples of like public and private sector programs converging (eg lucerne and phalaris breeding) and there is a project currently evaluating the incorporation of new technologies (eg markers) into existing breeding programs. *The meat industry has only limited connections with the developments of GM forages – such forages are likely to contain valuable traits but may pose significant industry and market challenges. Either way, GM forages is a development that must be built into this theme.* *The long term result needs to be breeding programs more rapidly developing new and better cultivars leading to greater uptake of new cultivars on-farm*

Comments and rationale behind the recommendations

- The points of market failure are complex and the market failure assessment framework will be critical in determining where MLA should invest. There are international spp (white clover, lucerne, perennial rye and to a lesser extent tall fescue) that are a major focus for the seed companies. However, MLA has invested in marker assisted selection and (via Pastures Australia) new breeding technologies but these innovations are yet to be incorporated into conventional breeding. MLA investment should be focussed on pre-breeding (see traits & technologies) where the private companies tend to under-invest. There are a number of other important species for the meat industry that do not have international programs (eg phalaris, sub-clover) and based on importance to the industry and addressing the market failure assessment may justify MLA investment – either directly into breeding or into pre-breeding.

- The MLA Donor Company model is already in use in the breeding of perennial ryegrass in the Dairy Futures CRC ("Pre-competitive facilitated adoption of molecular genetic technologies by pasture plant breeding companies"). It seems a highly effective way of partnering with commercial breeding companies to support adoption of improved breeding technologies by the private sector and so produce better varieties for Australian meat producers faster. Producing better varieties faster than would otherwise be the case is the justification for MLA investment into existing breeding programs.

- The grazing industries do not have an agreed list of priority pastures/forages to guide MLA investment in this theme. Without such a list, it was not possible for the feedbase project review workshop to effectively 'screen' project proposals. To compare projects on tall fescue endophyte discovery; reducing toxicity in phalaris, new white clovers or new lucernes that are Al tolerant requires a higher level of industry priority setting. There are some current activities that must be completed before further investments are made:
  1) MLA has initiated an audit of the feedbase across southern Australia. There are few data available on the importance of particular pasture species to the southern livestock industry, and there is no relevant data collected by ABARE, the seeds industry or government agencies. Local data on pasture species and mixes that contribute to livestock production will be collected. This will provide opinions of regional specialists, to provide a "quantitative" basis to assist MLA and its research Agency partners make informed decisions about research investment into the feedbase area.
  2) The 1000 Minds survey is developing weightings for specific traits based on the views of expert users (agronomists and farm consultants) and producers. The project is defining the focus of breeding objectives and selection criteria for different pasture species across production systems. The 1000 mind survey project to determine the economic weighting on traits could be expanded and development progressed with industry to fully engage producers, private and public sector breeding programs in key traits, weightings and access to related breeding technologies to achieve their desired outcomes.

- In theme 3 (traits and technologies) the same issue arises, but at the traits level rather than the

species level – ie if phalaris is priority species, then what are the traits that industry funding should focus on? MLA should implement a process (expert inputs, workshops etc) to develop and then build industry support around lists of priority species and traits. Such a process would provide an 'industry informed' basis to re-evaluate the projects submitted to MLA in the recent project call. Without such a list, it is possible that the feedbase project evaluation workshop has incorrectly rejected projects that in fact focus on the industry priorities. Determining this list would also address the feedback from the feedbase project evaluation (see Appendix F) and the PISC agency review (see Appendix I) - indicating that many projects require a detailed market assessment prior to any agreement to progress.

- Improvements in pasture species for which there are existing breeding programs will continue to be an important area for MLA investment. It is recommended that MLA allocates an indicative annual budget of $300,000 for this theme despite the fact that no projects are ready for an immediate start

Table 4. Summary information (scope, outcomes, assumptions, etc) and rationale for the recommendations made for the ***new traits & breeding technologies*** theme

R&D Pillar	**Pasture Breeding and Evaluation**
Theme 3	**New Traits & Breeding Technologies**
Scope	*This theme seeks to discover/define/develop new traits or new technologies for incorporation into breeding programs. Like the breeding programs themselves, this theme focuses on those regions where sown pastures are a major forage for meat production.*
Outcome	*Australian meat producers are able to increase productivity and profitability through MLA investing in pre-breeding activities that identify new traits for breeding programs or that provide breeding programs with better technologies.*
Key Assumptions	- *Currently available local cultivars, or those available from international breeding programs are sub-optimal for Australian conditions;* - *There is market failure associated with pasture breeding companies failing to invest in* o *the discovery of new traits important to Australian meat producers;* o *diagnostic processes to rapidly assess presence of key traits in early generations* o *the development of breeding technologies (such as genomics) or novel processes to increase the efficiency of pasture breeding.* - *Traits of significance identified by the industry (eg phosphorus efficiency; drought tolerant; persistence) are not readily measured, or it is difficult to select elite parents very early in a breeding program;* - *Improved pasture species and cultivars are particularly important to leading meat producers who are more likely to be involved in re-sowing and to understand the associated cost benefit relationships;*
Recommend-ations	9. *That MLA focuses half of its direct (ie levy funded) investment in pasture breeding into this theme to improve rate of genetic gain in priority species as per the model outlined in theme 2 and in recommendation 4 above (adoption of the grains industry model).* ***Action** - Scoping traits/technologies to improve the rate of genetic gain in priority species*
	10. *MLA initiates processes to maximise the incorporation of the resulting IP (new technologies and traits) from this theme in relevant public and private sector breeding programs.* ***Action** - MLA explore models to facilitate the transfer of this IP into breeding programs, including an "open source" approach making the IP freely available to all breeding companies.*
	11. *That the projects submitted for this theme (including the project on phalaris toxicity recommended by the feedbase project review workshop – see Appendix F) be re-assessed in the light of the outcomes of recommendation 5 above (ie MLA should establish and build industry support around a list of priority species and priority traits for those species). Implications of GM technologies should also be considered.* ***Action** - Scoping the priority pre breeding traits in target species* ***Action** - Use the pre-breeding priorities to re-assess project proposals for MLA investment*
	12. *That MLA allocates an indicative annual budget of $600,000 for projects in this theme.*
Building on	*Both existing breeding programs and the novel/niche species themes would benefit*

the theme	*from new traits/technologies. Development of processes for the early detection of desirable traits and so selection of elite parents could decrease breeding timelines, while screening accessions from genetic resource centres can identify what lines carry the majority of key traits.* *There should also be some focus on development of a methodology to assess feasibility of modifying a plant's genetics to accommodate new traits and therefore what species (domestic/ exotic) are best targeted for development.* *The result must be a dramatic change in the delivery of genetic gain in forage species through the provision of traits and technologies to increase the rate of genetic gain and the description of these new cultivars in terms of relative on-farm impact.*

Comments and rationale behind the recommendations

- The proposed model to guide MLA investments into pasture breeding and evaluation has been outlined in Section 4 of this report. Acceptance of this model leads to the following conclusions:
    - That the primary need for industry investment into pasture breeding and evaluation is into the identification/quantification of new traits and the development of new breeding methodologies – genomics being a clear, current example.
    - That industry has a responsibility for oversight/QA processes to ensure seed industry variety trials deliver appropriate information to assist producer decisions on seed selection.
    - That the private sector is primarily responsible for near market and commercial activities even if some industry investment is justified.
    - This investment in pre-breeding was recommended by the feedbase project review workshop to receive 50% of all MLA investments in pasture breeding and evaluation.

Table 5. Summary information (scope, outcomes, assumptions, etc) and rationale for the recommendations made for the ***novel species*** theme

R&D Pillar	**Pasture Breeding and Evaluation**
Theme 4	**Novel Species**
Scope	*This theme seeks to develop novel forage cultivars or species for adaptation into local environments or production systems. Generally there will be no current breeding programs for these species and the focus will be on regions where there are major opportunities to increase meat production with the establishment of novel forage sources.*
Outcome	*Australian meat producers are able to increase productivity and profitability through the incorporation of novel species into their feedbase.*
Key Assumptions	- *There are pasture/forage species with the potential to make a significant improvement in the productivity/profitability of meat production enterprises with further development;* - *The gains from individual novel species will be greatest when there is currently no reasonable options for the particular niche identified;* - *That development of novel or new species is a more effective way to achieve the desired outcome than modification of an existing cultivar.*
Recommend-ations	*13. That MLA builds a generalised framework/template that assists with the assessment of likely benefit and the commercial feasibility so as to guide investment in novel species. The external review of Tedera should provide a starting point for this general framework.* ***Action** – Contract the development of a framework for assessment of benefit & feasibility of novel species* ***Action** – Use the framework to re-assess project proposals for MLA investment* ***Action -** that MLA advise proponents of projects on novel species of the need to develop a skilled and realistic assessment of the likely benefits and risks associated with these species before requesting funds for further development. MLA may consider co-investment in this market analysis subject to perceived demand*.
	14. That MLA allocates an indicative annual budget of $200,000 for this theme.
Building on the theme	*There were several projects submitted to MLA in the recent call and these may offer significant benefits for the meat industry once MLA has completed recommendation 13 above and has an agreed assessment process.* *One of the most critical issues for this theme is to build strong links with theme 3 in Grazing Management & Production Systems (ie Integration of additional feeds into productive systems). This is because the value for meat producers comes not from the 'additional feed' that a new or novel species might provide, but from integrating that feed source into a productive and profitable system.* *The long term result needs to be that novel species are developed in an integrated way that addresses not only the breeding and selection of new lines but also likely grazing management, agronomic and commercialisation issues that are critical for success.*

Comments and rationale behind the recommendations

- The issue of investing in new and novel species vs deciding to improve the yield, quality, range or other characteristics of a species/variety currently in use is a real challenge. In this area more than most, the promises are large but historically, the outcomes have been modest. How is the excitement associated with finding a new plant (in the desert, or on another continent) that might revolutionise the Australian meat industry, to be balanced with the reality that the chances of

commercial success are small?

- History says that introducing/developing such novel species is likely to be most successful if the selection process is focussed on environments or systems for which there are no currently (reasonably) adapted options. Good examples include tagasaste for deep sandy soils, or tall wheatgrass/saltbush for salty or waterlogged soils. However, a focus on such climatic/soil niches greatly restricts the ability of such a project to provide a sufficiently high benefit cost ratio to overcome the high risk associated with a novel species. If the niche environment is small, then the benefits per hectare must be very large to justify the investment.

- The MLA feedbase project review workshop (see Appendix F) was asked to adjudicate on projects that ranged from searching South America for new bromus spp; improving the nutritive value of old man saltbush; developing elite new shrub options (Enrich); improving native legumes; and developing completely new species such as Tedera. With no guidelines, this was an impossible task, leading that workshop to conclude that no projects adequately addressed the role of these species for top producers, their likely fit with existing systems or provided an adequate market assessment. The workshop recommended "*that MLA advise proponents of projects on novel species of the need to develop a skilled and realistic assessment of the likely benefits and risks associated with these species before requesting funds for further development. MLA may consider co-investment in this market analysis subject to perceived demand*."

  We agree with this recommendation and suggest that if MLA wishes to invest in projects associated with new/novel species that a generalised framework/template be developed to guide both the development and assessment of such projects. This template will need to help project proponents develop a 'skilled and realistic assessment' of their proposal and help investors assess the potential value from their investment.

  MLA has commissioned a major review around the investment potential associated with Tedera. This review will have to assess all the issues associated with a novel species investment, but in this case for a specific new plant. At the completion of the review of Tedera, it should be relatively easy to build a generalised template to guide the assessment of any proposals for investment in novel species.

  Initially that template could be used to 'revisit' the project proposals already submitted in the recent call for feedbase projects. In the longer term MLA could make the template available for any individual or group who want to propose investments in novel species. Such an approach should prevent the current scatter-gun approach that characterises this investment theme.

9 The Productive & Sustainable Pastures Pillar in Detail

An overview summary of the Productive & Sustainable Pastures R&D pillar has been presented in Section 5 of this report.

The overarching goal of this R&D pillar is to increase pasture 'performance' and reduce costs of production per unit of forage, through the development of new tools and technologies to better manage the pasture feedbase for productivity and sustainability.

The challenges for the Productive & Sustainable Pastures R&D pillar include:

- → Merging the 'soils' pillar into Productive & Sustainable Pastures, including the development of a productive soils project across the key agro-ecological zones, but without losing the strong focus on productive and sustainable pastures;
- → Forming a coherent and focussed response to the Phosphorus review;
- → Recognising that while the initial focus is on P and N, other nutrients (eg K and S) and other soil based challenges (eg soil acidity) are important regionally and/or nationally;
- → Turning a fragmented package of work into a focussed R&D pillar;
- → Understanding (and focusing on) the particular challenges being faced by 'leading producers' who are the target for this R&D pillar;
- → Providing coverage of improved and unimproved pastures;
- → Ensuring the right balance between production and NRM goals;
- → Keeping pace with the emerging focus on soil carbon via the Carbon Farming Initiative;
- → Bringing a focus onto feedbase solutions for a hotter, drier and more variable climate;
- → Developing a leading edge program of work around the highly important (to producers) but experimentally difficult issue of 'pasture persistence';
- → Reviewing (with the objective of developing a leading edge program of work around) pasture health.

There are three 'themes' in the PSP pillar, and these themes are outlined in detail in Tables 6, 7 and 8. For each theme there is a desired outcome, key assumptions, recommendations/immediate actions, and the supporting rationale. The three themes are:

1. Productive Soils (Table 6)
2. Pasture agronomy & management (Table 7)
3. Healthy pastures (Table 8)

Table 6. Summary information (scope, outcomes, assumptions, etc) and rationale for the recommendations made for the ***productive soils*** theme

Program	**Productive & Sustainable Pastures**
Theme 1	**Productive Soils**
Scope	*This theme seeks to identify/overcome the factors which limit the chemical, physical or biological fertility of pasture soils and that therefore limit pasture production.*
Outcome	*Australian meat producers have access to the knowledge tools and skills to identify and profitably overcome soil based limitations to pasture performance. The focus is on key soil nutrients such as nitrogen and phosphorus, soil biology (including soil carbon) and soil physical limitations to pasture production.*
Key Assumptions	- *Increases in soil nitrogen supply can have a profound impact on the growth of companion grasses as well as on the value of the pasture phase to following crops;* - *Adoption of new tools and technologies associated with more productive soils will be high because of the long history of fertiliser use in cropping and grazing enterprises;* - *Building up soil carbon increases soil 'fertility' and with the incoming Carbon Farming Initiative, meat producers may have access to new income sources;* - *Efficiency is the overarching consideration in this theme as the management of pastures requires efficient/effective use of human, financial, and physical resources;* - *The increased focus on productive soils will not reduce the focus on pasture agronomy less focussed*
Recommend-ations	*15. That MLA builds 'productive soils' into Productive & Sustainable Pastures rather than having a separate Soils R&D Pillar.* ***Action** – Accept Figure 1, with 5 R&D pillars as the basis of the Feedbase Program*
	16. That MLA immediately progresses 2 of the recommendations from the feedbase project review workshop with the aim of funding from July 2011: *a. A consolidated project "Improving the efficient, effective and economic use of phosphorus in pastures" with an indicative budget of $650k per year.* *b. A project on N fixation based around the submitted project 'Optimising nitrogen (N) supply to grass based pasture systems' (PAM 5) with an indicative budget of $300k/yr. This project is to be expanded to address legume content and persistence.* ***Action** – finalise and contract a) for a July 1 start; further development for b)*
	17. That MLA recognises the emerging importance of soil carbon because of the legislation of the Carbon Farming Initiative and makes an indicative allocation of $60k for 'preparation' in 2011/12, rising to perhaps $250k per year in 2012/13 for R&D. ***Action** – monitor progress of Federal legislation re the Carbon Farming Initiative*
	18. That MLA and the RMCiC partners collectively invest to explore further opportunities in the productive soils theme with a focus on "Productive Soils" across the agro-ecological zones and with overt links into the soil biology component of the efficient use of phosphorus program, and the developing (2011-12) "Pasture Health" theme. ***Action** – Begin scoping a Productive Soils program including soil health and soil carbon*
Building on the theme	*Interactions with the Pasture health theme are critical. Projects addressing soil health directly link with pasture production, and common areas should be*

	developed - such as soil biology and root damage compromising pasture growth. *A new soil program and focus on carbon should extend from the carbon- nitrogen – phosphorus dynamics being explored in the phosphorus efficiency project. Interaction with GRDC in strategic science around nutrients and soil biology must be developed. Carbon- nitrogen modelling can be developed with the Australian Centre for Ecological Analysis and Synthesis, profiling the nutrient and health status can expand on the current DAFF initiatives in this area and the National Committee on Soil & Terrain.*

Comments and rationale behind the recommendations

- In the original RMCiC feedbase plan, 'Soils' was a separate R&D Pillar. However, the issues associated with soils are so intimately related to pasture production and utilisation, that the Productive & Sustainable Pastures narrative (see Appendix C) and the feedbase project review workshop (see Appendix G) have recommended incorporation of 'Soils' as a theme within 'Productive & Sustainable Pastures". The suggested focus for the Productive Soils theme includes: optimising and sustaining productivity and plant water use efficiency; recognising and minimising adverse soil processes; and avoiding nutrient imbalances through evaluation and management.

- In 2010 MLA funded a major review of phosphorus R&D and called for projects in response to the review as part of the call for pasture agronomy and management projects. The result was a large number of relatively independent projects that the feedbase project review workshop was unable to adequately assess. The workshop recommended that MLA immediately initiate a process of consolidation and coordination using the research teams and leading producers to develop a cross agency project that addresses the issues raised in the phosphorus review.

- The feedbase project review workshop also recommended that while P is critical, other nutrients must be included in the investment mix and therefore MLA should progress a project on soil N based around the submitted project "Optimising nitrogen (N) supply to grass based pasture systems – PAM 5" that is led by NSW I&I at Wagga, but includes input from TIAR (Launceston), SARDI (Adelaide), CSIRO (Canberra) and Charles Sturt University (Wagga). However, PAM 5 requires some significant further development activities to ensure relevance to pastures with less than 600mm annual rainfall, focuses more on existing perennial and annual legumes rather than new/novel legumes such as Tedera and builds in design input from and on-going links with leading producers.

- Soil organic matter has always been an important element of soil fertility, boosting soil structure and providing the base material for most of the nutrient recycling that occurs in soils. One of the vital processes that underpins the long term sustainability of rotation farming is that soil organic matter depleted during cropping phases can be re-built during the pasture phase and so on. The Commonwealth Government is legislating the Carbon Farming Initiative to provide financial incentives for farmers to sequester carbon into soils and vegetation. The 'Productive Soils' theme will need to be ready to explore the option for expansion into the carbon sequestration area once the legislation is clear/enacted, and when the national soil carbon project funded by DAFF reports on the impact of farming/grazing systems on soil carbon sequestration opportunities. That is, a watching brief for 2011/12 with a likely expansion into R&D projects in 2012/13.

- This theme, as currently outlined is highly fragmented. Soil P has been comprehensively reviewed and therefore we can have confidence in the project recommended in 16a above. However, there is much more to 'Productive Soils' than P fertiliser and there are likely to be important gaps in this theme that should be explored during 2011/12 as a priority for MLA and the RMCiC partners. The feedbase project review workshop was clear regarding the need to focus effectively on the broader concepts of soil health and nutrient balance and not just on soil

P. Soil biology, and the potential to boost nutrient recycling within a pasture system and between a pasture and cropping phases should be explored. The workshop recommended that MLA evaluate the establishment of a nationally coordinated 'research' project focused on profiling the current "nutrient and health" status of various soils supporting pasture and livestock production across the agro-ecological zones of southern Australian. This should focus especially on the soils associated with the top 20% of producers.

Table 7. Summary information (scope, outcomes, assumptions, etc) and rationale for the recommendations made for the ***pasture agronomy & management*** theme

Program	**Productive & Sustainable Pastures**
Theme 2	**Pasture agronomy & management**
Scope	*This theme is focussed on producing more and better (timeliness or quality) pasture, and on maintaining pastures in a productive state long term. It is also about linkages to information from soils on the one hand to animal performance and NRM outcomes on the other and collating this information into feedbase management strategies.*
Outcome	*Australian meat producers are able to improve the productive capacity of their pastures (quantity, quality and timeliness) and to maintain those pastures in a productive state for longer as a result of MLA's investment in the Productive & Sustainable Pastures theme.*
Key Assumptions	- *That significant gains in livestock and cropping performance are available on many meat producing properties if there was more focus on pastures being fit-for-purpose. That is right pasture, right place, right management and right animal production system.* - *Because of the history of R&D, the knowledge around pasture agronomy and management is significantly greater for southern temperate pastures than for northern sub-tropical and mixed temperate/tropical pastures suggesting low hanging fruit.* - *Improving the performance/consistency of legumes in mixed pastures would dramatically boost animal and crop performance (pasture quality and increased yield from N fixation) and confidence to increase stocking rates.* - *The inability of sown pastures to persist is one of the greatest barriers to re-sowing pastures. An improved focus on achieving persistence would greatly increase pasture re-sowing rates and pasture performance across most agro-ecological zones.*
Recommend-ations	*19. That MLA enter into negotiations with those agencies that submitted project proposals focussed on the performance of sub-tropical pasture species (and companion spp) for both sub-tropical and more southern regions to collectively determine the potential for a MLA investment of around $250k pa.* ***Action** – join with interested agencies to explore the potential for a profitable investment in sub-tropical species agronomy & management.*
	20. That, in response to the submitted project "New temperate perennial grasses for improved profitability and sustainability of red meat production in southern Australia (PAM 35)" MLA works with the FFI CRC to ensure a rapid delivery (including agronomy/management packages) of the new cocksfoot, tall fescue and phalaris cultivars to the commercial partner. ***Action** – the short term aspects of PAM 35 to progress to benefit cost analysis and approval with a likely investment of up to $250k.*
	21. In the Productive Soils theme, there is a recommendation to progress a project around optimising N fixation - this project should be expanded into a cross theme project. The objective would be to explore with interested agency partners the question of how to increase the consistency of legume performance in particular, and the issue of 'companion species' more generally. ***Action** – join with the productive soils theme and other interested agencies to explore the potential for a significant investment ($250k/a) in legumes/companion species/N fixation.*
	22. That MLA join with interested RMCiC partner agencies to undertake a major

	exploration of the issue of 'understanding and achieving persistence' (possibly linking to the role of companion species in recommendation 21) in pastures that are important for southern red meat production, to collectively determine the needs around a potential MLA investment around $250k pa. ***Action** – collectively investigate the potential and likely returns from a significant investment in persistence, working directly with the PBE theme where alternative mechanisms for the collection and collation of producer data regarding pasture performance/persistence under grazing and in mixed swards are being investigated.*
Building the theme	*This theme has several 'investigation' projects where there is a need for collective review before project level decisions can be made – these investigations may grow this theme significantly.* *Low cost methods for improving pasture performance need to be developed to reduce the need for re-sowing in those areas where re-sowing is an option, and to provide options when re-sowing is not possible and/or economic. This may include novel methods for improving the content of desirable pasture species, from recruitment strategies to partial resowing/seed coatings etc. A pasture improvement/ renewal strategy should be developed and campaign progressed based on market research, farm data and case studies.* *This theme needs to deliver agronomy and management strategies for all the important pasture types (from native through to fully exotic pastures) that underpin meat production.*

Comments and rationale behind the recommendations

- There are 3 key challenges that need to be addressed in terms of pasture agronomy and management for productive and sustainable pastures. These are having the pasture mix that is fit-for-purpose; getting the best performance out of that pasture; and persistence, or keeping that pasture in a highly productive state for an extended time. These 3 challenges are discussed below.
  - The basic agronomy of traditional pasture species in southern Australia has been well researched, from establishment techniques and forage production/quality profiles, through to grazing management and likely animal performance. Even likely NRM outcomes are now quite well understood allowing producers to select pasture mixtures that will deliver the package of outcomes being sought. The primary, on-going challenge is how to manage the input resources to get the best bang per buck, and to establish information linkages from plant breeding through to animal and crop performance to ensure the pasture mix continues to be the best fit for the current purpose. Opportunities should be explored for more efficient resource use (human, financial, physical resources) seeking for example tactics / processes to lower cost of production.

    However, there were several project proposals submitted in the recent MLA call that indicate this high level of confidence in the agronomy and management of southern/temperate pasture species is not shared in the northern sub-tropical regions, nor in the intermediate zones where both sub-tropical and temperate species are potentially part of the overall mix. This should be investigated, and if there is a lack of basic agronomic information (eg companion species), a project should be developed as this could be relatively low hanging fruit.
  - The FIP consultations suggested that there is a major challenge in the meat industry associated with increasing the content of desirable species in pastures, and increasing the consistency of the legume component. The prospect of new or better legumes has been extensively discussed in the pasture breeding and evaluation R&D pillar but for most producers the question is how to manage the legumes that are already present in their pastures to perform consistently for both animal production and for soil fertility gains. The

importance of consistent legume performance is likely to be greater for top producers who are running higher stocking rates and pushing their systems harder and for producers who run a mixed farming enterprise.

There is a recommendation in the Productive Soils theme to fund a nitrogen project that aims to developing a clear understanding of N budgets for grass/legume pastures and guidelines for legume content requirements to meet the grass N needs. The proposed project will be monitoring 100-150 pasture sites for their N budget and it would seem sensible to add into this project the question about consistency of legume performance rather than commissioning a separate project.

There were many projects proposals submitted in response to the project call, that focused on the potential for 'zonal (ie sub-paddock scale) management' making use of technologies that might be aggregated under the heading 'remote and precision tools'. Discussion of these project proposals and the opportunity for zonal management has been included in the Grazing Management & Production Systems (GMPS) R&D Pillar. Project development (or not) will come from the scoping in that Pillar.

- The FIP consultations highlighted that the highest ranked plant trait across all agro-ecological regions was the need to breed for "persistence under grazing". Unfortunately, the trait most prized by producers is not such a high priority for plant breeders because:
  - Breeder's plots are almost never grazed; neither breeders' plots nor variety evaluation trials run long enough to assess persistence in producer terms; and more persistent pastures require re-sowing less often.
  - Persistence is less of a 'trait' and more of an 'emergent property' that results from 3 main factors – the initial selection (as some species/varieties are inherently more persistent than others); the management (especially grazing and fertility); and the climatic and biotic stresses experienced by the pasture.

In the Pasture Breeding & Evaluation R&D pillar, the challenges associated with testing species and cultivars for persistence was explored, resulting in a recommendation "*That MLA explores alternative processes to provide information on mixed sward performance, pasture persistence, and animal performance. Instead of costly demonstration or research trails, perhaps this might be based on the Wikipedia model of aggregating large amounts of lower quality data into reliable information.*" There are many reasons why persistence is difficult/near impossible to tackle from a standard R&D perspective and therefore it would provide an excellent 'pilot' for a process that was focussed on collecting scattered farm data (as its on farms, under realistic management where 'persistence' is expressed in producer terms) as envisaged in the PBE recommendation. The PBE scoping project should be expanded to incorporate the questions raised here about persistence.

Table 8. Summary information (scope, outcomes, assumptions, etc) and rationale for the recommendations made for the ***pasture health*** theme

Program	**Productive and Sustainable Pastures**
Theme 3	**Pasture health**
Scope	*This theme covers projects that aim to keep pastures healthy above and below the ground.*
Outcome	*Australian meat producers are able to maintain healthy pastures and therefore be more productive, persistent, and make more efficient and effective use of resources (soil, water, manpower, fertilizer etc).*
Key Assumptions	- *That sub-optimal pasture health is a significant cause of poor pasture performance and reduced pasture persistence.* - *Poor pasture health or soils that are classified as "unhealthy" are generally the result of abiotic and/or biotic stresses. For example, nematodes and soil pathogens can damage root systems and therefore impact on plants ability to access soil nutrient reserves – there is likely to be an interaction with soil biological activity* - *Pasture health issues have not been quantified, and cost to the meat industry have not been determined* - *Pasture health is directly linked to the pasture persistence issues discussed in theme 2 (pasture agronomy & management) and any developments in this theme should be implemented in association with that theme.*
Recommend-ations	*23. That MLA follow the pattern set by the Soil Phosphorus review and work collaboratively with interested RMCiC partners and the private sector to fully explore the challenges for the meat industry associated with improving pasture health. Project level investments are not recommended until 2012/13 to allow time for a full analysis of the issues and challenges* ***Action** – initiate a 'review' process with RMCiC partners*
	24. That MLA allocates an indicative annual budget of up to $200,000 for projects in this theme to give 'direction' to the process in recommendation 23 as it explores a 'pasture health' research project. Improvements in performance and persistence should be explored.
Building the theme	*The Pasture Health theme is the least developed theme across the whole feedbase R&D program. A major review and development process is required, with strong links to soil biology, abiotic and biotic stress research, above ground management (grazing & nutrient application) and all work associated with "pasture persistence". Understanding and communicating the importance (weightings) of each factor by region can be developed from a cross theme analysis.*
Comments and rationale behind the recommendations • A terms of reference needs to be developed if recommendation 19 (Understanding pasture persistence) is accepted. Clearly, abiotic and biotic stress (pests, diseases, climate) will be included, but it is appropriate to expand the scope to include issues associated with pasture plant symbiotic relationships (rhizobia for N fixation and endophytes for insect protection) and with pasture impacts on animal health. This review process will place MLA and the RMCiC partners in a good position to determine if there are priority projects that might be developed to begin in July 2012.	

10 The Grazing Management & Production Systems Pillar in Detail

An overview summary of the Grazing Management & Production Systems R&D pillar has been presented in Section 5 of this report.

The overarching goal of this R&D pillar is to increase profit by increasing the margin between cost of production and sales revenue. The role of research and development in grazing management and production systems is to optimise stocking rates through better managing pasture utilisation in concert with enterprise flexibility and to fit these into a business management framework. These changes must improve labour efficiency, optimise pasture management for production and NRM outcomes, produce agricultural systems that are resilient to seasonal variation, manage risk and delivers product that meets market specifications and community expectations.

The challenges for the Grazing Management & Production Systems R&D pillar include:

- → What are the particular grazing management and systems challenges being faced by 'leading producers' who are the target for this R&D pillar;
- → Determining the balance between R&D on system components (where the R&D is more straight forward), and/or R&D at the whole system level, and/or modelling (system or component);
- → Finding the right balance for the pillar between high tech (eg satellite monitoring) and lower tech solutions and between science push and producer demand pull;
- → What is the 'right' balance between work on high vs low input systems and profit vs NRM outcomes;
- → Bringing some focus to the issue of managing meat production systems in a hotter, drier and more variable climate;
- → How to ensure delivery, given that recent reviews have suggested work in this production systems area, while being scientifically interesting and challenging, has not led to much change on farm;
- → Rotational grazing systems have not been able to demonstrate significant gains in livestock production or profit, despite positive impacts at the pasture (production and composition) and NRM levels (groundcover, nutrients), and some indications for an economic advantage if the reduced need for pasture re-establishment is taken into account.
- → Keeping a systems focus on the multiple requirements - maintaining sown pastures, increasing utilisation, better matching supply and demand, meeting animal production/turnoff targets, integrating with crops, shrubs etc.

There are three 'themes' in the Grazing Management & Production Systems pillar, and these themes are outlined in detail in Tables 9, 10 and 11. For each theme there is a desired outcome, key assumptions, recommendations/immediate actions, and the supporting rationale. The three themes are:

1. Pasture and livestock indicators (Table 9)
2. Livestock systems design (Table 10)
3. Integration of additional feeds (crops, shrubs, niche pasture species and containment feeding) into productive systems (Table 11).

Table 9. Summary information (scope, outcomes, assumptions, etc) and rationale for the recommendations made for the ***Pasture and livestock indicators*** theme

R&D Pillar	**Grazing Management and Production Systems (GMPS)**
Theme	**Pasture and livestock indicators**
Scope	*This theme focuses on understanding how meat producers can make use of the dramatic increase in 'precision agriculture' possibilities (involving remote sensing, individual animal identification, GPS mapping and computing power) to make better day to day decisions. Though the technologies and their applications may vary, this theme has potential applications in all agro-ecological zones but will probably focus initially in mixed farming zones where precision agriculture is already an established technology for cropping.*
Outcome	*Meat producers are able to make much better informed tactical grazing and other management decisions to optimise stocking rate, livestock and pasture performance and livestock health and welfare despite seasonal and market fluctuations, through the effective collection (with an emphasis on remote collection) and use of objective data/indicators.*
Key Assumptions	- *Many management decisions that significantly impact farm performance and profit are limited by a lack of clear pasture and livestock indicators on which to base those decisions.* - *Activity and performance indicators are important in all meat production systems, from the most extensive to the most intensive.* - *There have been major advances across a range of sensing and computing technologies and in combination, these could offer significant gains to meat producers.* - *Remote sensing of pasture growth has proven technically competent but has not delivered on producer expectations in New Zealand, Victoria and Western Australia. Finding the value proposition for producers will be the challenge for this theme.* - *Variable seasons and markets require adjustment to management tactics – existing analysis (soil water, species biomass, sunlight) can be coupled with forecast information (growth rate, probability of wet/ dry conditions) to assist tactical management of individual paddocks and animals herds/ mobs.*
Recommend-ations	*25. That MLA and the RMCiC partners undertake a major 'background investigation process' with the aim of identifying the potential for a significant R&D investment (MLA ~$500k/yr+) in the general area of 'precision agriculture'.* ***Action** – This precision agriculture review will require a budget of ~$125k in 2011/12 and is more than a literature review – the challenges is can these novel technologies be integrated and delivered in ways that underpin better (more timely, more informed etc) management decisions and a supporting business case for development and delivery. Value must be determined, ensuring this is a demand and not supply driven development.*
Building on the theme	*While this theme offers exciting possibilities, there are no plans or recommendations regarding further development until the comprehensive review/investigation recommended above is completed and clear opportunities are defined.* *If projects are developed and there is on-going investment into this theme, then close links must be established with soils, pasture and livestock management programs.*
Comments and rationale behind the recommendations	

- There are many background factors to consider when thinking about improvements to grazing management and production systems, for example:
  - industry benchmarking projects routinely report that the main distinguishing features of the most profitable livestock producers are higher stocking rates, better pasture production and grazing management and superior genetics;
  - adoption of managerial innovations by the livestock industry is generally slower than adoption of product innovations because managerial innovations (e.g. grazing management, enterprise choices) are more far-reaching and challenge the way producers do business;
  - industry consultation undertaken as part of the FIP preparation found that of all the factors known to affect the productivity and sustainability of red meat production, respondents nominated pasture utilisation and grazing management of highest priority for on-going research;
  - the effect of grazing rotation on pastures is mediated principally through utilisation, frequency, severity and, in annual-dominant environments or with some pasture species, the timing of grazing;
  - while positive effects of rotational grazing for pastures and natural resources are now well documented, the flow through to improvements in animal production or profit is less clear.

- Major gains have been made in the grains industry through utilising remote and precision technologies to provide improved data on which to base management decisions. There were several projects submitted to MLA in the recent call that explored aspects of remote/precision data collection including satellite imagery of pastures and remote sensing of sheep behaviour. Other projects suggested a more traditional approach to optimising grazing system in-terms of stocking rate, paddock number, rotation speed and movement triggers for native and introduced pastures. The feedbase project review workshop recommended that rather than picking one or more of these projects, MLA should invest to drive greater collaboration between remote data collection innovations and empirical studies – ie potentially assimilating satellite information with on-ground data collection and remotely monitored animal behaviour. There are many things to consider in such an approach:
  - There have been rapid advances in many of the technologies, including the computing power needed to turn remotely sensed data into useful information to underpin day to day decisions;
  - Some of these technologies offer the potential for zonal (ie sub-paddock) information and therefore management decisions;
  - The grains industry has undoubtedly learnt many lessons about precision agriculture that should be investigated before a significant meat industry investment;
  - Integration across technology platforms is challenging and not the normal way for groups to interact suggesting producer/industry oversight will be needed;
  - Single remote technologies (such as satellite sensing of pasture growth rates) have struggled to achieve commercially viability – there are lessons to be gathered from the trialling of this technology with meat producers in WA and in the dairy industry in both Victoria and New Zealand;
  - Can a combination of technologies (from low to high tech) provide meat producers with the appropriate ‘pasture and livestock indicators’ and deliver what the single technologies have been unable to achieve;
  - This theme is not about ‘testing/developing’ the technologies per se, but about how to integrate these technologies into a management system that provides indicators of pasture and animal ‘performance’ to underpin better (more timely, more informed etc) day to day management decisions.

- In summary, this is an exciting area for an ‘integrating investment’ but the subject is too complex and the technologies probably too separated to simply ‘pick a project’. A major ‘investigation’ of

the possibilities and the prospects is needed to guide what might be a major industry investment. This 'investigation' is not simply a review of the literature, though reviewing the 'state of play' for some of the individual technologies might form part of the package. Other things to consider include how to achieve significant producer input, how to learn from other industries, how to keep the focus on systems rather than the individual technologies, how to investigate the potential for zonal management decisions, and how to commercialise/deliver any outcomes. This investigation should be undertaken as a joint venture between MLA, any interested RMCiC partners and potentially the 'owners/developers' of the remote and precision technologies.

Table 10. Summary information (scope, outcomes, assumptions, etc) and rationale for the recommendations made for the ***Livestock systems design*** theme

R&D Pillar	**Grazing Management and Production Systems (GMPS)**
Theme	**Livestock systems design**
Scope	*This theme is similar to "Pasture and animal indicators" in that it focuses on understanding how meat producers can make optimal use of resources and the dramatic increase in 'precision agriculture' possibilities but to underpin better strategic (system design) as well as tactical (day to day) decisions. Though the technologies and their applications will vary, this theme has potential applications in all agro-ecological zones.*
Outcome	*Meat producers are able to capture and interpret remote and local data into the design of more profitable livestock systems. These improved systems integrate grazing and other management inputs into a focus on optimising enterprise mix and meeting market targets despite seasonal and market fluctuations.*
Key Assumptions	- *That strategic system design [around stocking rate, pasture utilisation, grazing management and resource allocation (human, physical and financial)– key factors that separate top from average producers] is a major driver of farm profitability.* - *That the suite of technologies outlined in the 'pasture and livestock indicators' theme offer significant potential to underpin not just tactical decisions, but also strategic systems design decisions.* - *Design of a livestock production system must achieve multiple outcomes across the triple bottom line. Financial, environmental and social benefits are critical in the success of a business in the short and long term.* - *Livestock production systems utilise both native and improved pastures. On many properties, the spatial arrangement of that feedbase can improve both production and NRM outcomes.* - *Modelling to identify synergies, tradeoffs and opportunities across the triple bottom line of any intervention will be a significant component of this theme.*
Recommend-ations	*26. That the major 'industry investigation of remote and precision technologies' that was recommended in pasture and animal indicators be broadened to include data capture to support strategic (systems design) as well as tactical decisions.* ***Action** – Contract the precision technologies project to include systems design issues. This is a major 'review' process and no projects should be contracted until it is completed.*
	27. That MLA explores other options (other than the remote and precision technologies in recommendation 2 above) to improve systems design and resource allocation in livestock system design with the overt aim of reducing costs of production and achieving the required NRM and social outcomes. ***Action** – negotiate with the FFI CRC to modify the EverGraze native pasture site at Orange to include assessment of high density grazing and opportunities to reduce inputs and costs with a budget of up to$150kpa.*
	28. That EverGraze systems modelling be focussed on addressing seasonal variation and ensuring market specifications, by incorporating sub tropical species, and new temperate grasses and management tactics. ***Action** – That MLA invest up to $200kpa into EverGraze system modelling*
Building on the theme	*The main distinguishing features of the most profitable livestock businesses are higher stocking rates, better pasture production and grazing management and*

	superior genetics. Against this background, the industry is speculating about the relative benefits of high density grazing and low input systems. This theme should lead a detailed investigation using quantitative and anecdotal data – not to try and prove which is 'the best', but to assess how to get the best out of each system alone and in combination. Animal production and ecological benefits, as well as resource allocations, work load, risk, stress should be assessed from different livestock system designs in both high and low input systems. *This theme should have close association with the "Decision Support" pillar and with animal breeding and performance programs to ensure a consistent message around 'best genetics (plants/ animals) best management, best feeding for the desired business purpose.*

Comments and rationale behind the recommendations

- See discussion in Theme 1 – pasture and livestock indicators – as most of the issues and challenges are similar for assisting strategic decisions as was discussed for tactical decisions. The capture and interpretation of remote and local data is a powerful addition to considerations of enterprise, market specification and risk exposure in terms of system design. Grazing management is an important component of resilient agricultural systems that can support high stocking rates while minimising climatic fragility and risk exposure. Given the importance of stocking rate and grazing management to enterprise profitability and environmental sustainability it is critical that attention of the research, advisory and producer community remains focused on assisting producers not only get the tactical decisions right, but to have the appropriate pasture/animal system design.

  The question of optimal system design must include consistency with the aspirations of the individual producers. Appropriate design of a livestock system is concerned with resource use efficiency – physical, financial and human – and with the 'fit' with other business enterprises. Integration is a major challenge for this theme to optimise design and tactics in both high and low input systems.

  Whole farm systems research is not feasible in most situations, but despite this, there are two critical tools available to this theme:
  i. Modelling (and therefore links with the decision support pillar) is the 'scientific' mechanism to explore the potential systems implications from management interventions;
  ii. Inputs from leading producers who are working on these tactical and strategic challenges every day and therefore provide a major resource for the theme.

- While the remote and precision technologies are high tech and offer exciting possibilities, this theme must explore better design processes for lower tech and lower input systems. The FFI CRC (EverGraze) site at Orange has begun to explore high density grazing on native pastures and the opportunities to reduce inputs on pasture establishment and soil fertility while maintaining production and has the opportunity to explore design issues around landscape position and the influences on soil C sequestration, total and available N.

  Critically, all projects in this theme must consider scenarios broader than the feedbase in order to address livestock system design. Addressing a production issue may be achieved by a change to either the target market, animal management calendar, enterprise mix, animal genetics or the feedbase – or any of these options in combination so all should be explored. Increases in pasture utilisation need to be carefully managed because high rates of utilisation, particularly during the growing season can reduce pasture growth rate, shift botanical composition and affect livestock performance through positive and negative feedback loops. Increases in stocking rates also need to be carefully managed because of the tension between individual animal production, production per hectare, seasonal variation and negative feedback on pasture growth. Enterprise flexibility (i.e. proportion of breeding and trading stock units) and

forward planning are key mechanisms to manage risk and ensure livestock meet market specifications.

Table 11. Summary information (scope, outcomes, assumptions, etc) and rationale for the recommendations made for the ***Integration of additional feeds into productive systems*** theme

R&D Pillar	**Grazing Management and Production Systems (GMPS)**
Theme	**Integration of additional feeds (crops, shrubs, niche pasture species, conserved fodder and containment feeding) into productive systems**
Scope	*This theme is about integrating forage options and feeding strategies into productive and profitable meat productions systems that are focussed on more effectively meeting livestock nutritional needs and market requirements, while improving the soil and pasture resource base. This theme has application across the high rain fall zone and the mixed farming zones.*
Outcome	*Meat producers are able to select and integrate additional forage options and management tactics (including containment feeding and forage conservation) into production systems to reliably meet livestock market specifications more profitably than conventional pasture based systems.*
Key Assumptions	- *That integrating additional feed sources into productive systems will assist meat producers to confidently and profitably increase stocking rates, reduce costs per kg of product, better meet market specifications and/or aim for higher value markets* - *Some tactics (eg shrubs, forage conservation, containment feeding) may have significant NRM benefits in some environments and can double as drought feeding strategies* - *Spatial arrangement (link to design theme) of that feedbase is required deliver the production, profit and NRM outcomes, thereby ensuring efficient use of resources.*
Recommend-ations	*29. That MLA and CSIRO begin negotiations around the project "Achieving a step change in HRZ livestock production by capitalising on dual purpose cropping" with the objective of sharing the cost with GRDC and making linkages to extend the geographical reach of the project around an indicative budget of $350k/yr. Negotiations with GRDC and other researcher should progress to expand the intent of this project into the cereal zone of utilising crops for livestock production* ***Action** – the development needed here is relatively minor so a July 1 start is appropriate. Negotiations should progress with GRDC, CSIRO, CSU and other research providers aiming to extend the geographical reach of the project and sharing the costs.*
	30. That MLA negotiates with the FFI CRC to progress part of the 'Enrich' project - to focus the project on integration and to reduce the budget from ~$920k to ~$250k/y. ***Action** – given that Enrich is an existing project, this development should proceed quickly. Additional funding for the methane assessment from shrubs investigations (currently DAFF funded) should be sought from the MLA methane program, rather than feedbase investment.*
	31. That MLA and the RMCiC partners collectively invest to explore the question of how to most effectively utilise crop stubbles in mixed farming operations without damaging soils and the yield potential of future crops and potentially fund a project in this area. ***Action** – explore both the literature and producer knowledge before developing any*

	projects. $60k is allocated for this review and planning.
Building on the theme	*Resource use efficiency and spatial arrangement of interventions / tactics are primary themes across all related project in this Pillar (Grazing management and production systems) and in Productive & Sustainable Pastures.* *Modelling is a major tool that can be used to address key 'what if' questions and therefore strong linkages to the Decision Support pillar are essential.* *Developing research topics from GRDC's Grain & Graze 2 on integration will value add to that program and the need to address the integration of pastures, crops, livestock and nrm outcomes.* *While the initial focus for the recommendations is the mixed farming zone, this theme must expand to more fully explore the issues and challenges for the other key regions.*

Comments and rationale behind the recommendations

- These are a group of tactics to assist producers better match feed supply with animal demand. However, it is not just about filling a feed gap as the optimal solution at the systems level might be to change the animal production system or genetics, or the target market(s). In addition, this theme is about implementing productive and profitable systems and not about drought feeding strategies though of course some of the tactics (eg shrubs, fodder conservation or containment feeding) may deliver multiple benefits for NRM outcomes and drought management.

- This theme is not about evaluating components, but is about incorporating additional forage/feeding options (options that have well defined/proven agronomic or production characteristics) into more productive, sustainable and profitable systems. Many of the project proposals submitted around this theme were focussed on evaluating new or niche species and were therefore more suited to the 'Novel Species' theme in the Pasture Breeding & Evaluation R&D Pillar. A good example of integration into systems (and why the project was recommended by the feedbase project review workshop) is the project "Achieving a step change in HRZ livestock production by capitalizing on dual-purpose cropping" – dual purpose crops are a proven technology and the challenge is to get the best out of including them into a production system. The limitation with this project is its narrow geographic focus, but that could be broadened by linking in producers who are wanting to work on incorporating dual purpose crops into their systems. Including DPIV and NSW I&I into the project could bring these producer links and a broader spread across those areas where dual purpose crops are grown.

- The prospects for shrubs in grazing systems has been widely touted, and there are some examples of dramatic productivity increases – leucena in northern systems, tagasaste for the sand plains and old man saltbush for salty environments. There are often multiple benefits from including shrubs in farming systems, but this can lead to over-promising a suite of benefits from biodiversity, carbon sequestration and erosion prevention, to increased animal production, health and welfare. The MLA feedbase project review workshop recommended that some aspects of the Enrich project be funded but that this would "*require considerable modification to change or narrow the research focus and reduce the budget*". The focus of any project should be on the production/profit potential from integrating shrubs into grazing systems, rather than the potential for NRM, methane reduction or other outcomes. These 'other outcomes' will almost never be realised if system does not deliver on the basic promise of increased profit and thus a return on the investment. In addition, there are quite a few 'other shrub projects' currently funded and therefore some 'overview' process should be enacted before deciding on the specifics of any MLA funding into Enrich. A workshop with representatives from these projects

and with producers who have some experience with shrubs might be an effective process.

The opportunity for additional funds to explore the potential for methane reducing bioactives in some of the shrub options should be explored via the DAFF/MLA national methane research program (RELRP).

- In the recent call for project proposals, MLA received some project proposals around the grazing of stubbles. This has been a significant focus for the Grain & Graze program and there has been a 'stubble assessment tool' developed. However, it seems that many cropping farms and mixed farms are reluctant to graze stubbles because of potential downsides to future crops through soil structure or weed problems. Rather than fund a single project on stubble grazing guidelines, the project review workshop recommended that MLA explore the impact of grazing stubbles more broadly, with the aim of developing the tools and technologies that will allow mixed farmers to get the livestock benefits from grazing stubbles while avoiding any negative impacts on future crops.

11 The Appendices

- Appendix A – Summary of the Feedbase Investment Plan (FIP)
- Appendix B – PBE Narrative
- Appendix C – PSP Narrative
- Appendix D – GMPS Narrative
- Appendix E – Details of the call for project proposals
- Appendix F – PBE workshop report
- Appendix G – PSP workshop report
- Appendix H – GMPS workshop report
- Appendix I – RMCiC pastures sub-committee strategic directions
- Appendix J – MLA strategic directions
- Appendix K – Feedbase R&D Plan BCA

Appendix A

[Brief Summary of the FIP Research Component[1]]

Feedbase Investment Plan

R, D & E Priorities for the Southern Australian Feedbase

January 2011

Report: Feedbase Investment Plan	Report Date: 14th November 2010 Edited Report Date: 24th November 2010 Edited Report Date: 12th December 2010 Final report Date: 14th January 2011
Report prepared for: Cameron Allan Project Manager, Pastures & Resource Management Meat & Livestock Australia North Sydney NSW 2060	Report prepared by Project Team of: Mr Jim Shovelton, Mike Stephens & Associates Dr Lewis Kahn, Agricultural Information & Monitoring Services Mr Geoff Thomas, Thomas Project Services Emeritus Professor Jim Pratley, Charles Sturt University Mr Charles de Fegely, Mike Stephens & Associates
	Contributions to the report from: Mr David Hudson, SGA Solutions Pty Ltd Dr David Lloyd (interviews QLD)
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[1] This summary has been prepared by Warren Mason to give an overview of the research section of the FIP. It is not a comprehensive summary of the FIP and if further detail is required, the FIP is available from MLA

Background

Meat and Livestock Australia (MLA) has taken a lead role within the red meat co-investment partners and commissioned the development of an Investment Plan for the research, development and extension that underpins the Southern Australian feedbase. The Southern Australian feedbase is defined as herbage provided by pastures, grazing crops and shrubs from sown, naturalised and native plant species within the area south of the 26° line of latitude. The objectives of the Feedbase Investment Plan were to:

- Document feedbase priorities and industry deliverables that increase meat profitability and sustainability for the 6 southern agro-ecological regions that underpin the national beef and sheepmeat RD&E strategies
- Develop a Feedbase Investment Plan (FIP), addressing strategic and applied research and delivery priorities and opportunities covering Southern Australia for at least the period from 2010 to 2020, for consideration by the Red Meat Co-investment Committee (RMCiC).
- Provide recommendations for management and coordination of such investment across the national RD&E framework, supported by the public and private sectors in the pasture industry supply chain.

Strategic fit

The feedbase industry requires a national focus and has "slipped between the cracks" of the national PISC process. It is an industry that makes its contribution indirectly through meat, fibre, dairy and grain and this accounts for its lack of recognition on a national scale. The contribution of the feedbase, and pastures in particular, to farm production and sustainable natural resource management deserves focused attention in a farm systems context. A similar conclusion emerged from the recent review of Pastures Australia which identified better industry collaboration leading to a more coordinated and efficient use of RD&E resources and capacity as key objectives.

A structure for delivery of RD&E has been proposed in this FIP that will establish the national focus and provide clear linkages throughout the industry. The recommendations are aligned with national and industry priorities as developed by MLA and the PISC process. The RD&E objectives have emerged from widespread industry consultation and establish an industry direction for the period until 2020.

Consultation

The approach taken to develop the Plan involved an industry survey followed by extensive consultation with key people representative of sectors and agro-ecological regions within the Feedbase industry. Consultation activities were supported by a comprehensive review of relevant documents, reports and existing activities, a situation analysis of livestock demographics, value and underpinning practices and orientation of the Investment Plan within the strategic policy environment.

The consultation process collected 576 responses from within the Feedbase industry. The scale of the consultation process and its stratification across industry sectors and agro-ecological regions provides a very sound justification for the recommendations contained within this report. The consultation used industry knowledge and many of the participants had experience from other RD&E programs. This knowledge provided a context and a filter about the state of the industry and informed responses about prioritising existing technologies likely to have the largest impact on the productivity and sustainability of red meat production. The value of consultation was also brought to bear when industry-experienced participants nominated research areas and projects to further improve the feedbase industry. There were

other benefits from the consultation such as identifying major barriers to adoption and capturing preferred and perhaps novel methods of extension and communication.

The Project Team used their industry experience and knowledge gained from the review process to build the consultation responses into a workable, strategic and innovative Feedbase Investment Plan (FIP). The short and long –term goals for the feedbase industry put forward in this FIP will be achieved by increasing the margin between cost of production and price received per unit product.

Table 2: Guiding framework used to develop the Feedbase Investment Plan

Aspiration	Double red meat production from half of the area currently used for grazing
Goals	1. Increase by 30% the productivity and profitability of red meat production by 50% of producers by **2015**, through the adoption of existing information and practices. These changes will also lead to improvements in the sustainability of natural resources and quality of life of industry participants. 2. Increase by a further 30% (i.e. 60% increase from year 2010 position) the productivity and profitability of red meat production by 50% of producers by **2025**, through the adoption of information and practices to emerge from research programs. These changes will also lead to further improvements in the sustainability of natural resources and quality of life of industry participants.
Objective	Increase the margin between cost of production and price received while managing risk and improving the natural resource base
Actions	*Research and extension programs to target at least one of the following actions:* 1. Decrease cost of production • Reduce the contribution of overheads to the unit of production • Match pasture supply and demand • Optimise marginal economic return from variable inputs 2. Increase the unit value of production by meeting market specifications 3. Improve the condition of the natural resource base 4. Manage risk exposure associated with production

Existing technologies for adoption

Industry responses indicated considerable improvements to the profitability (22 – 55%) and sustainability of red meat production from adoption of existing technologies and further gains to be generated from research activity. With only some exceptions, there was substantial consistency among the agro-ecological regions as to the **current** issues regarded as of top priority for adoption. Ranking of existing technologies indicated emphasis should be given to adoption pathways that address the following:

1. Better pasture utilisation	6. Better integration of crops with pastures
2. Improved grazing management	7. Improved control of weeds
3. Improved soil fertility	8. Correct soil pH
4. Increased legume content	9. Increased use of fodder crops
5. Increased sown perennial grass content	10. Increased subdivisional fencing

Delivery structure

Information regarding delivery is not included in this summary because the MLA board has requested further investigation of what role MLA should play in delivery.

Research programs addressing future needs

The clear message from the consultation process was that importance should be given to:

Research programs that address improving the utilization and management of the existing feedbase, providing greater integration with farming systems and the whole farm business, and then improve pasture choices through evaluation and selection programs.

9.3 Conclusion and FIP research investments

Given this body of information it is now possible to recommend levels of investment in the FIP and the probability of successfully transforming the outcomes and outputs of research into a more profitable and sustainable red meat industry. While human capacity is likely to be sufficient, in the short-medium term, for the conduct of the proposed research (albeit requiring a greater team approach), the chance of success (i.e. industry transformation) is considered to be highest for pasture production and lowest for the areas of plant improvement and evaluation. This is not considered to be an impenetrable barrier to these program areas but highlights the importance of industry linkages at early stages of the research in order to ensure that collaborative arrangements with the private sector are complete.

On the basis of the discussion in this FIP a budget is proposed to support a research program over five years to achieve the deliverables outlined in the FIP. A total budget of $19.0M is required to support the proposed research areas over a period of 5 years (Table 34) which is calculated from the estimates of cash requirements and industry impact collected through the consultation. This amount represents 9% of the industry investment over the five year period.

Table 34: Recommended level of financial support for each research program area

Research Program	Major theme	Investment ($M/5 years)
Plant improvement	Evaluation and selection programs	1.7
	Legumes	2.2
	Phalaris	1.5
	Subtropical species	0.5
Pasture production	Pasture nutrition	2.5
Pasture harvest	Grazing management	4.0
	Pasture management	1.5
Production systems	Integration of crops, pastures and livestock	3.5
Evaluation	Farm system models	1.0
	Financial benchmarks	0.6
TOTAL		19.0

Plant improvement

It is expected that there will be greater public benefit from public sector investment in germplasm enhancement and platform technologies such as genome sequencing with private sector engagement in cultivar development. The species targeted for public investment should be those which are unlikely to attract stand alone private investment.

It is recommended to:

Establish an independent plant evaluation and selection program using appropriate genetic and genomic technologies to improve a range of pasture traits such as increased persistence, lower nutrient (fertiliser)

requirements, higher quality feed and out of season production. The evaluation will be built upon a network of linked sites that provide uniform and independent genetic evaluation of pastures species and investment in germplasm enhancement and platform technologies such as genome sequencing. The keystone species for improvement are legumes (lucerne, medic, sub clover), phalaris and subtropical species. *Allocated budget is $5.9M over a 5-year period*.

Establish a formalised process for collection and analysis of pasture seed sales for Southern Australia.

Pasture production

Research will address improvements in the efficiency of fertilizer use by better testing and application regimes and better harnessing of soil biological processes. The key nutrient is phosphorus but attention to sulphur and potassium is also recommended. *Allocated budget is $2.5M over a 5-year period*.

Pasture harvest

The objective is to develop grazing systems for better utilisation of pastures and shrubs, which encourage perenniality, and which achieve high livestock performance with high labour efficiency. There is a need to develop indicators or trigger points to best determine appropriate rates of utilisation and livestock rotations that fit agro-ecological regions, enterprise mix and risk exposure profiles. *Allocated budget is $5.5M over a 5-year period*.

Production systems

There are market signals that are encouraging a greater integration of crops, pastures and livestock in traditional mixed farming regions and also those with higher rainfall.

The major objective is the need to develop systems to better integrate livestock and the pastures that support them with cropping enterprises, with primary attention to the role of grazing cereals, legume break crops and the strategic use of containment feeding. *Allocated budget is $3.5M over a 5-year period*.

Evaluation

The major themes are further development of farm system models that will assist with climate adaptation, financial performance and system optimization and analysis of farm system options for profit, risk, labour and natural resource management. Models are a basic building block of RD&E programs and this will support greater focus on key areas. In addition to sophisticated models there is a role for simple tools which capture the key performance indicators of farms and are used in the extension process. *Allocated budget is $1.6M over a 5-year period*.

The objectives and deliverables anticipated for each of these research areas is outlined in Table 29 on the next page.

Table 29. Research program areas, themes, objectives, deliverables, time frame and agro-ecological relevance for investment in the feedbase of Southern Australia.

Research Program	Major themes	Research objectives	Deliverables	Time frame (years)	Agro-ecological relevance (1,2,3)[A]
Plant Improvement	Evaluation and selection programs	• Implement an independent plant evaluation and selection program using appropriate quantitative genetic and genomic technologies to improve the persistence, quality and productivity of existing keystone species and evaluation of new species.	• A network of linked sites that provide uniform and independent genetic evaluation of pastures species. • Investment in germplasm enhancement and platform technologies such as genome sequencing.	6 - 9	(1) Temperate Slopes and Plains (1) Temperate Highlands (1) Wet Temperate Coast (2) Sub Tropical Slopes and Plains
		• Selection to provide the base pasture traits identified through the consultation process. These traits are required for all the pasture species which are listed below. Species specific traits, in addition to the deliverables for this objective, are provided below.	Base general pasture traits: • better persistence under grazing and moisture stress • lower phosphorus requirements and/or higher nutrient extraction efficiency • higher feed quality and production • out of season production • better seedling vigour • lower animal health toxicity		All
	Legumes	• Selection to increase the tolerance to low soil pH and mixed-sward compatibility of **lucerne** • Selection of shorter-season **medics** with better seed production and **sub clovers** with greater consistency across variable seasons	• Lucerne cultivars with greater tolerance of low soil pH and better compatibility in a mixed sward (i.e. grass/lucerne) • Medic cultivars with a shorter season and better seed set for recruitment and sub clovers with greater adaptation to climate variability	6 - 9	(1) Temperate Slopes and Plains (1) Temperate Highlands (2) Wet Temperate Coast
	Phalaris	• Selection to reduce phalaris toxicity and increase aluminium tolerance	• Phalaris cultivars with lower toxicity for livestock and better aluminium tolerance	6 - 9	(1) Temperate Slopes and Plains (1) Temperate Highlands (2) Wet Temperate Coast
	Subtropical species	• Selection of legumes for better adaptation to sub-tropical grass pastures • Selection of Subtropical grasses for adaptation to southern Australia	• Legumes better adapted to persist in sub-tropical pastures • Subtropical grasses adapted to southern Australian soil and climate	6 - 9	(1) Sub Tropical Slopes and Plains (2) Temperate Slopes and Plains
Pasture Production	Pasture nutrition	• Improve the efficiency of fertilizer use by better testing and application regimes and better harnessing of soil biological processes.	• Improved precision of nutrient status determination , pasture requirements and application technologies to enhance the marginal return from on-farm fertilizer applications • Greater understanding of soil biology and its role in reducing fertilizer requirements	6 - 9	(1) Temperate Highlands (1) Wet Temperate Coast (2) Temperate Slopes and Plains (2) Sub Tropical Slopes and Plains
Pasture Management and Harvest	Grazing management	• Develop grazing systems for better utilisation of pastures and shrubs, which encourage perenniality, achieve high livestock performance with high labour efficiency.	• Grazing rotation indicators (e.g. stock density, graze and rest periods, pasture residuals) for different feedbase systems, enterprises and agro-ecological regions • Demonstration of the linkages between optimal rates of pasture utilisation (% of pasture growth) and stocking rate decisions (including seasonal variation) • Development of trigger points for matching stocking rate to planned rates of utilisation • Evaluation of the impact of grazing rotation and pasture utilisation strategies on livestock performance, risk exposure, profit and sustainability	3 - 6	(1) Arid Interior (1) Semi arid Sub Tropical Plains (1) Temperate Highlands (1) Wet Temperate Coast (1) Sub Tropical Slopes and Plains (2) Temperate Slopes and Plains
	Pasture management	• Develop information to allow management of pastures to fill feed gaps for increased persistence, quality and productivity in a variable climate.	• Integrated systems that fill feed gaps including the role of forage crops and fodder conservation • Management strategies to increase the consistency of the legume content of pastures	3 - 6	(1) Temperate Slopes and Plains (1) Temperate Highlands (1) Wet Temperate Coast (2) Sub Tropical Slopes and Plains
		• Develop more labour efficient approaches to sheep production	• Evaluation of ways to improve labour efficiency of sheep production	1 - 3	All
Production Systems	Integration of crops, pastures and livestock	• Develop systems for better integration of livestock and the pastures that support them with cropping enterprises. Primary attention to the role of grazing cereals, legume break crops and the strategic use of containment feeding.	• Development of the technical basis for the role of livestock in mixed enterprises for managing crop diseases, risk and impact on profit • Evaluate the strategic role of containment feeding in mixed cropping/livestock feeding	3 - 6	(1) Temperate Slopes and Plains (1) Sub Tropical Slopes and Plains (1) Semi arid Sub Tropical Plains (1) Temperate Highlands (1) Wet Temperate Coast (2) Arid Interior
Evaluation	Farm system models and financial benchmarks	• Further develop models that will assist with climate adaptation, financial performance and system optimization.	• Analysis of farm system options on profit, risk, resource management and labour • Analysis of the impact of climate change in models to predict species abundance and feedbase productivity	1 - 3	All

[A]Agro-ecological relevance (1) top priority; (2) moderate priority; (3) low priority.

Appendix B

Plant Breeding and Evaluation Narrative

A summary report prepared for the MLA FIP Investment Project Review Workshop

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April 2011

Plant Breeding and Evaluation Narrative

1. Executive/Plain English Summary

The investment profile and delivery structure for forage plant breeding and evaluation has been the subject of numerous reviews and changes in recent years. There is an increased emphasis of examination of the role of government in investment and a desire for the private sector to invest in near market and commercial activities. This has seen an increase in the number of public:private partnerships and a focus of public sector and industry investment in generic technologies and areas of market failure. This process has been endorsed by the PISC R, D & E process and is consistent with recent developments in plant breeding investment and delivery in the grains and horticulture industries.

A number of MLA reviews including the recent FIP have highlighted potential areas for MLA investment that are consistent with this overarching framework and have the potential to add value to the Australian red meat industries through the provision of improved forage genetics to an informed market place. These include:

- Development of objective evaluation programs
- Development of technologies to describe and increase genetic gain in forage species
- Development of programs that develop and utilise modern genetic tools (genomics, bioinformatics, quantitative genetics etc) to provide novel tools and traits for forage plants
- Extending the range of adaption of existing species through selection

This narrative will briefly outline recent outcomes from plant breeding investment and suggest some factors that should be considered when commission pasture plant breeding and evaluation research in the future.

2. Insights and Priorities from MLA and the FIP consultation

MLA has directly (through the FIP process) and indirectly (through the Pastures Australia Review process) canvassed the opinions of a wide range of stakeholders in recent times including:

- Public sector investors and science agencies
- Private sector breeding companies
- Seed wholesalers and retailers
- Agribusiness consultants
- Producers

As some of MLAs recent investments and co-investments were managed through Pastures Australia the following review of stakeholder perceptions regarding Pastures Australia projects can be used to illustrate the fact that in general terms respondents are more favourable to projects with general

applicability as opposed to those that were perceived to have a more regional or niche focus (Figure 1).

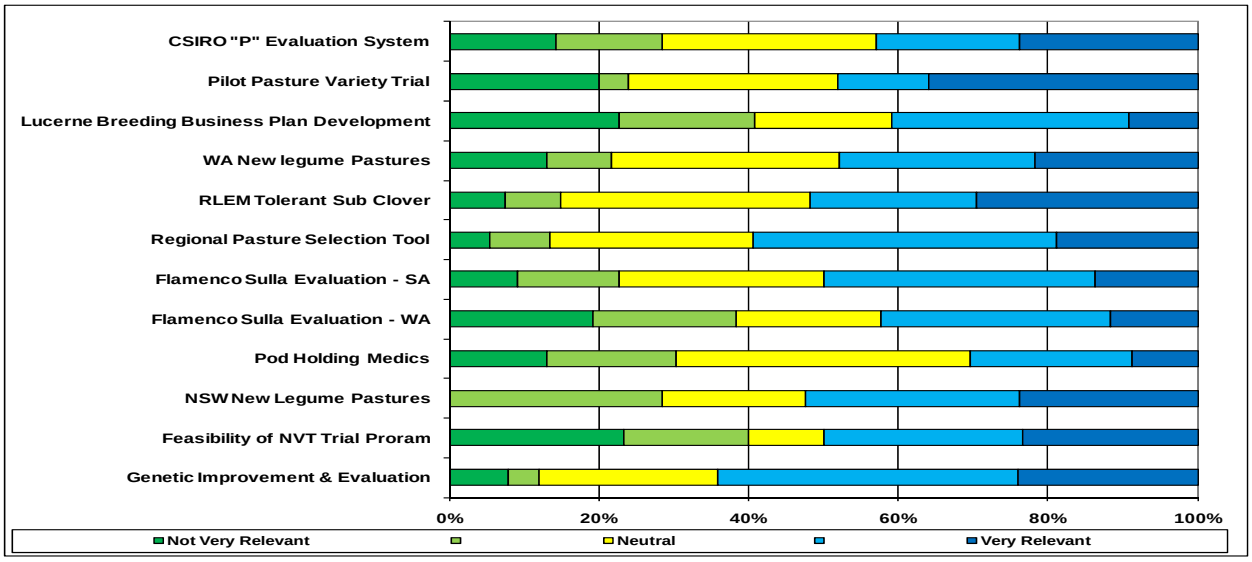


Figure 1. Summary of responses with respect to the PA research portfolio (source Pastures Australia Review: D Hudson 2009).

The FIP process commissioned by MLA in 2010 also recommended that plant breeding and evaluation was an important area for investment with themes around incorporating new technologies (quantitative genetics and genomics), regional evaluation of the merits of pastures and the development of persistent perennial grasses and regionally suitable legume species identified as possible themes for further research.

What is missing in these reports is a gaps analysis of how well current pasture cultivars, either those used commercially or those available for use but not broadly commercialized, fit the requirements of leading producers who are a key target of the Feedbase Investment Research which is currently being considered.

Because of this lack of information the following assumptions have been made during the construction of this narrative

- That well adapted, productive pastures that are well utilized are major drivers in reducing the cost of production for beef and lamb in southern Australia
- That objective information is needed to describe the value of new plant genetic innovations in Australian farming systems
- That genetic innovations have the potential to provide both incremental and step-change improvements in productivity and profitability
- That public:private partnerships will be critical to the success of delivery of genetic innovations to producers in two key ways
    - Providing ‘step change’ innovations into species with mature commercial programs

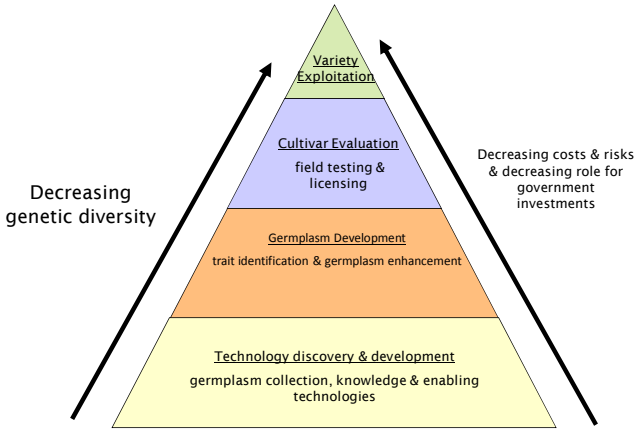
- Development of germplasm and/or management packages for those environments/species where 'market failure' is judged to occur.

There are generally three key drivers for investment in plant breeding research and development

1. The possibility for incremental gain (for instance a higher yielding replacement cultivar, or extension to the area of adaption for a cultivar/species)
2. The possibility of step-change technologies (such as genomics, GM etc) to radically change a pasture system
3. 'Market failure' in terms of providing novel genetics into a given environment or production system.

All of these are valid drivers for investment and have different levels of attraction depending on whether the investor is a Government department, MLA or private seed company. Area 1, is becoming widely accepted as a role for the private sector, with 2 & 3 the largely the domain of the public sector or private:public sector partnerships. The attraction of private sector funds into areas 2 & 3 can be limited by the size of the forage seed market relative to major food crops such as cereals, maize etc.

An example of the relative level of government investment in plant breeding is given in the following diagram that has been adapted from a version used by DPI Victoria.



An analysis of the Australian seed market (Table 1) demonstrates that the temperate seed market is dominated by several major species perennial ryegrass, short term ryegrass, tall fescue, sub clover and lucerne and as there are active private sector breeding programs in these species there has been a reduction in government support for private sector breeding programs starting with the reduction of MLA and DA funding to perennial ryegrass in Victoria in the late 1990s.

Table 1 also demonstrates that whilst there are large numbers of cultivars in the market, a relatively small number of cultivars dominate the market in each species. Recent reviews in wheat

and barley have also shown this to be true and in both instances it is broadly adapted cultivars that dominate the market despite many programs breeding for regional and sub-regional adaptation. This point is critical as it is clear that companies currently strongly market broadly adapted cultivars whether they are bred in the private or public sector.

Table 1. Australian Pasture Seed Market (Source Gout Report to Pastures Australia 2006)

Species	Cultivars	Sales (t/pa)	Value ($M)	Top Cultivars	Market Share (%)
Perennial ryegrass	44	2400	9.6	8	56
Short term ryegrass	48	7000	21.0	13	82
Tall fescue	20	650	3.9	7	81
Cocksfoot	8	210	1.3	2	64
Phalaris	9	180	1.1	4	69
White clover	20	600	4.2	8	56
Red Clover	8	150	1.4	3	69
Sub clover	27	1700	7.7	6	61
Other clover	28	800	2.4	4	70
Medic & serradella	33	1000	5.0		
Brassicas	30	490	2.9	5	65
Herbs	12	200	2.0	2	65
Lucerne	43	2100	14.7	7	51
Tropical Grasses	30	1100	8.8		
Tropical Legumes	26	1400	7.2		
Total	386	19980	93.2		

Breeding of novel species or adapting existing species to stress environments has long been a feature and success of pasture breeding in Australia, with some notable successes such as the domestication of *Phalaris aquatica* in the CSIRO Canberra program (Oram and Lodge 2003, Culvenor 2009) and the successful commercialisation of medics, subterranean clover, Persian and balansa clovers from a long running range of initiatives that have culminated in the recent NAPLIP and Future Farm Industries CRC programs (eg Dear *et al.* 2003; Dear *et al.* 2008). Australia has led the world in the domestication, breeding and commercialization of these species. However, despite significant government investment a number of other species have failed to find commercial success despite showing good promise in trials and selection, such as summer dormant perennial ryegrass (Reed *et al.* 1999), sainfoin, lotus and sulla (Dear *et al.* 2003; Dear *et al.* 2008) with the potential value of these species known since at least the 1960s. Despite the large and concerted effort has been placed on alternative legume breeding and selection and the number of cultivars released the market remains small with only a few cultivars successfully commercialised (Table 1). Whilst this can be expected to some extent due to investment in an area of market failure there is rarely an attempt to understand the cause of market failure before a breeding program is

undertaken. The assumption is sometimes that the market will grow once suitable cultivars are developed.

A better approach would be to conduct a thorough market analysis before the commencement of a breeding program for novel species and environments to identify the reasons for existing or potential market failure so that product development funds can be spent accordingly. The development of tools for the successful remediation of market failure (Figure 2) can then commence prior to commercial release.

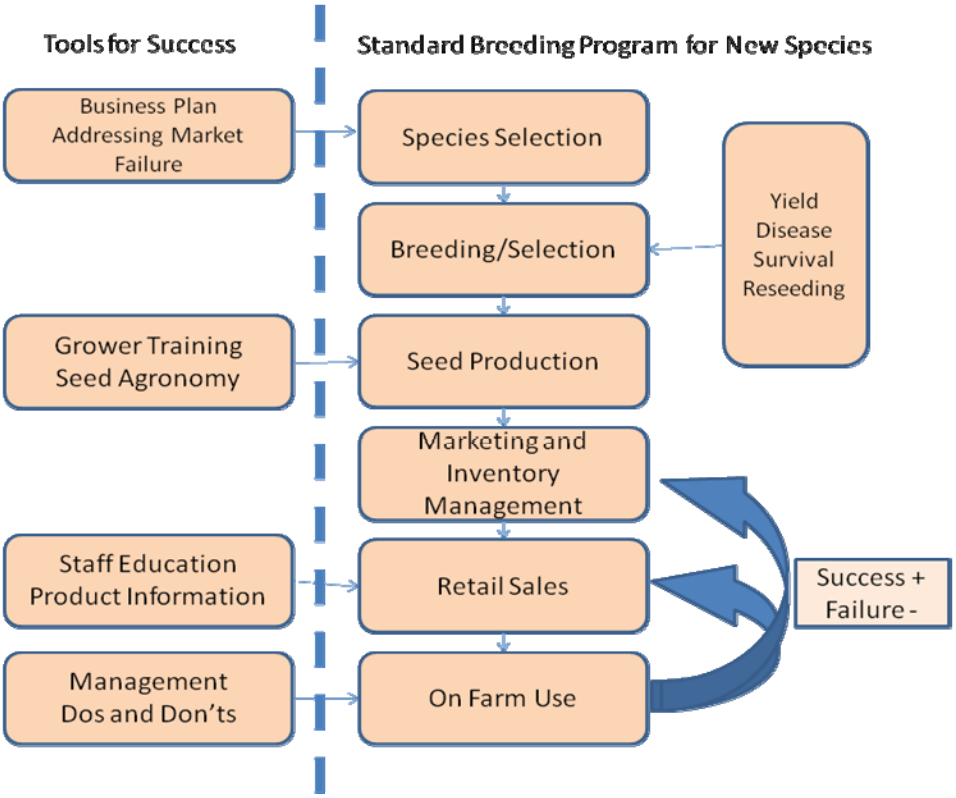


Figure 2. Schematic outline of breeding and commercialisation of new species

Once the limitations of a pasture in a given environment are identified a key decision relates to whether these are best addressed through improvement of an existing species or the introduction of a minor species. This is still a major question today and recent research has seen investment in both approaches.

The following general observations on the state of genetic improvement in pastures in Australia come from a recent MLA report (McRae *et al.* 2005) and provide a good basis for understanding the MLA drivers in this area of science.

General Observations on Genetic improvement in Pastures (McCrae *et al.* 2005):

• There is a perception that conventional pasture breeding in the major species of pastures has been effective and further investment is no longer required to develop more cultivars. We do not support this position, but argue that conventional breeding could be done much more effectively in

most pasture species, and private industry should fund this activity. There is a large amount of heritable genetic variation for most plant characters in pasture species that is currently underutilised.

• There appears to be a fundamental shift in direction towards biotechnology and niche species, but this strategic investment must be kept in balance and not at the expense of conventional breeding in the major species.

• There have been too many breeders (researchers) working on various aspects of pasture improvement with predominantly a research based agenda, rather than having a commercial focus on delivery of improved cultivars to industry.

• There is a perception that there will be a shortage of trained pasture breeders in the future. A systematic approach to breeding and genetic evaluation will make more efficient use of specialist geneticists, and free up scientists' time to tackle outstanding research issues.

• Breeding and selection strategies are not well documented and have loosely defined goals. There has also been a tendency to improve characters independently of other traits, and pursue issues of 'fashion'.

• The breeding objective(s) is loosely defined in biological terms, rather than in economic terms. Although it is likely that many of the important biological traits in pastures have been identified, it is unlikely that appropriate emphasis has been placed on the traits that are driving profit in the red meat industries.

• Biological models differ for the main pasture species: the legumes including lucerne (*Medicago sativa*), white clover (*Trifolium repens*), subterranean clover (*T. subterranean*) and medics (*M.trunculata*, *M. littorallis*, *M. polymorpha* and *M. tornata*), and grasses, including perennial ryegrass (*Lolium perenne*), cocksfoot (*Dactylus glomerata*), tall fescue (*Festuca arundinacea*) and phalaris (*Phalaris aquatica*). Some species are obligate self-pollinators, some partial selfers, and others obligate out crossing.

• White clover, lucerne and perennial ryegrass dominate the global market for temperate agriculture. Although important in Australia, other species like subterranean clover and medics are considered novel overseas. As a consequence, multi-nationals may not be interested in breeding for these small and diverse markets.

• In general, there has been a short term focus on breeding and genetic improvement. There has been a tendency to sample many accessions (ecotypes) from the naturalised range of the species, and then to test these selections for adaptation in the pastoral and/or cereal-pasture zones. Backcrossing is often used to infuse desirable traits for resistances to pests and diseases into established cultivars. Synthetics (mixed pedigreed populations) are usually released for commercial production.

• There has been a tendency to rely on phenotypic mass selection for capturing gain in particular traits, with limited management of pedigree at the individual plant level. It is likely that long term genetic gain can be greatly improved by utilising more controlled pollination, testing and selection of individual genotypes, and pedigree management.

3. Recent R&D and Key Current Investments

Noting the fact that the structure, management and funding of pasture breeding investments in Australia is in a state of transition the following section illustrates some of the major MLA

investments in this area in recent years. It does not attempt to summarize all investments nor does it attempt to assess whether they met all of their stated objectives.

Niche/New/Market Failure Initiatives

One major program of investment in this area has been the suite of activities within the CRCPBMDS/FFICRC which has sought to develop a range of pasture plants targeted to either particular (stress) environments or to extend the range of adaptation of existing species. The following table illustrates part of the process that the CRC partners used to prioritise their research activities.

Table 2. Summary of current perennial legume and grass breeding activities for recharge areas, and identification of gaps in the target areas.

Breeding activities	Current knowledge	Gaps
Perennial legumes		
Lucerne	Cultivars available for neutral to alkaline soils, resistance available for common pests and diseases	Water-logging tolerance, salinity tolerance and cultivars for acidic soils
Birdsfoot trefoil	Cultivars available for high rainfall areas of southern Australia. Tolerant of water-logging and acid soils	Medium to low rainfall areas, better persistence under drought conditions
White clover	Successful in areas with more than 800mm annual rainfall	Medium to low rainfall areas (below 800mm/ yr)
Sulla	Breeding almost limited to mediterranean Europe. Good drought tolerance in alkaline areas	Neutral to acid soils, Tolerance to heavy grazing, prostrate types.
Perennial grasses	*Management is an issue in all grasses: weed control, soil fertility, grazing tolerance. Need species for medium to low rainfall areas with better drought and acidity tolerance and increased persistence*	
Perennial ryegrass	Suitable for high rainfall, fertile areas - dairy areas of Australia	Drought tolerance, benefits of 'safe' endophyte, increase into medium rainfall areas
Tall Fescue	Long growing season. Some tolerance to waterlogging and soil acidity	Benefit of 'safe' endophyte, increased drought and acidity tolerance
Cocksfoot	Reliable on acidic sandy hill country of low fertility	Enhanced performance in low-medium rainfall including wheatbelt
Tall wheat grass	Good summer activity. Developed for discharge regions, some salt tolerance	Better cool season activity
Phalaris	Deep-rooted, therefore dries out soil profile. Drought tolerant	Sensitive to heavy stocking, contains undesirable alkaloids, intolerant of acid soils

Native grasses	Number of elite lines selected for medium - high rainfall environments	Species/ ecotypes for medium to low rainfall environments. Improved seed yield and ease of harvesting required.

Cultivars from some of these programs are either reaching the market or are the subject of proposals for further work on agronomic evaluation. This table illustrates biological/agronomic gaps and imperatives that were used to prioritise activities within the CRC.

There are a number of other initiatives to develop cultivars of novel species and for greater ranges of adaptation within both the public and private sectors. It is outside the scope of this document to review all of these initiatives.

Another significant factor in this area is the number of cultivars developed in isoclimatic regions internationally that are starting to find their way into the Australasian market. In some cases these are the result of joint efforts between Australasian research agencies or companies and partners in Mediterranean Europe, USA, Argentina and Uruguay and reflect the global nature of the global seed industry and a significant potential for Australian investors and researchers to partner to achieve outcomes in pasture plant breeding.

Innovation in Species for which a Mature Market Exists

An example of this area of science that has involved MLA co-investment is the projects with DPIV/MPBCRC/DFCRC/DA/GGDF to develop molecular marker technologies for forage species. This project commenced with the development of a toolbox of marker technologies

- AFLP
- SSR
- SNP

in white clover and perennial ryegrass in all cases this was world-leading research conducted in germplasm relevant to Australian conditions and focussed on traits related to forage quality and stress tolerance.

Once these marker technologies were developed it became possible to utilise the markers for a range of activities that would form part of the strategy for implementing candidate gene based markers in forage plant breeding including

- Designing novel breeding strategies
- Understanding the basis of self-incompatibility
- Identifying genes involved in forage quality and genetic variation within these genes
- Using DNA fingerprints to identify and discriminate white clover cultivars

This program is now funded through a donor company project piloting the application of these technologies in a world's first application of candidate gene based markers in a commercial forage breeding program.

Potential use of the MLA Donor Company Model for Funding

The history of MLA co-funded white clover program provides a good example of the partnership that can be required to take plant breeding products to market including agencies, commercial partners and the role of MLA in facilitating the linkage between the two. It also illustrates the evolution of the funding mechanism to the donor company model.

The White clover program

Initially, the program focussed on setting up a germplasm resource centre, developing and characterising an internationally sourced germplasm collection and undertaking a 'plant X environment matching study' to determine breeding objectives. This work was funded jointly by Australian industry funds (Wool, Dairy, Meat R&D Corporations) through two funding cycles:

1. DAN 104 White Clover Improvement–National Field Testing of the Australian White Clover Collection (Ayres JF, Norton MR, Jahufer MZZ, FitzGerald RD, 1991/92–1994/95, Wool R&D Corporation/Dairy R&D Corporation)
2. DAN 074 Regional grazing management sites for NSW in Temperate Pasture Sustainability Key Program (FitzGerald RD, Ayres JF, 1993/94–1995/96, Meat Research Corporation).

The first breeding project was a rapid reselection process within Siral to develop a broad adaptation Haifa-replacement cultivar; funding was provided by a commercial partner:

3. Reselection within Siral - a white clover cultivar with broad adaptation to NSW dryland environments (Ayres JF, Caradus JR, 1995/96–1997/98, Agricom (New Zealand) Limited).

This was followed by two funding cycles to develop cultivars with tolerance of summer moisture-stress; funding was provided by Meat RC on behalf of Wool and Dairy RC's:

4. DAN 085 'National Temperate Perennial Legume Improvement Program – white clover breeding for dryland sheep and cattle pastures' (JF Ayres & JR Caradus, 1994/95–1996/97, Meat Research Corporation)
5. TR 041 'Australasian Perennial Legume Improvement Program - white clover breeding for dryland pastures' (JF Ayres & JR Caradus, 1997/98–2000/2001, Meat and Livestock Australia).

Most recently, there has been one funding cycle to develop 'dry margins' cultivars:

6. P 164 'Drought tolerant white clover cultivar for the dry margins' (JF Ayres & DR Woodfield, 2005–2008, MLA & Agricom (New Zealand) Limited).

From project 6 (P164), funding has been provided through the Australian Government 'Partnerships in Innovation' coordinated by the MLA donor company, with co-funding from Grasslanz commercial connections. A considerable strength of this funding model has been the seamless integration of breeding with commercialisation, both domestically and internationally, through active involvement of the commercial partner.

4. What's about to enter the Delivery Pipeline

Given the ongoing nature of plant breeding investment in Australia and New Zealand a range of new varieties will be released. The majority of these will be replacements for existing technologies, others like tedera (*Bituminaria*) represent the potential introduction of a new species into mainstream agriculture and are likely to require further development activities before commercialisation based on the likely market size and requirements for successful adoption.

5. Big Opportunities

One of the big opportunities is timing and a range of factors suggest that the current climate in pasture plant breeding research and development provide the opportunity to break out of the paradigm described in the introduction to this narrative:

- Relative maturity of a range of technologies that have been under development for a number of years including genomics, GM, markers, statistical genetics. These technologies provide the tools when integrated to address some of the stumbling blocks to increasing the rate of genetic gain in forages.
- A number of mature public:private partnerships that are linking technology with the marketplace

The big opportunity is most likely to come through the support of programs that seek to provide innovative solutions to producer problems rather than repeating the paradigms and programs of the past. Without identifying particular plant species or providers these are likely to include:

- Tools that describe the value of forage genetics in economic terms
- Programs that effectively target the 'omics' revolution that is occurring in bioscience to forage issues
- Programs that use market based assessment to provide solutions to 'market-failure' issues that preclude the effective provision of innovative genetic solutions to sectors of the Australian meat industry.

6. Conclusions and Recommendations

Due to the tight timelines for the project submission process and the need to submit this narrative for review concurrently with the indicative projects it has not been possible to assess the individual projects against these conclusions and recommendations rather the recommendations focus on factors specific to plant breeding and evaluation projects that should be considered when assessing the relative merits of the projects submitted. The recommendations do not cover generic principles such as value for money, co-investment, team performance etc that have already been provided to the project review panel.

This funding initiative represents a significant opportunity for MLA to deliver novel genetic innovations to meat producers particularly to those who are already adopters of new technologies. The following recommendations are grouped according to the type of project under consideration.

Niche/New/Market Failure Initiatives

- A true assessment of the market and reasons for market failure should be undertaken before projects are commenced if projects do not adequately assess this.
- Consideration should be given to 'route to market' issues as waiting to license a cultivar and then solve these issues adds a significant delay to the adoption of technology.
- Consideration should be given to targeting the technical issues that need to be addressed as part of the agronomy and farm systems research and development programs.
- Good initial progress could be achieved by reviewing what would be possible with technologies that are currently 'on the shelf'. Working out how to deploy a cultivar that is 80% right could provide a far better return on investment than developing one that is 90% right.
- Priority should be given to projects that seek to use integrated and innovative methods to reduce the time and cost that it takes to develop prototype products.

Innovation in Species for which a Mature Market Exists

- The opportunity here is to support step change technologies that benefit from existing routes to market and a mature commercial sector.
- In many cases the maximum value for MLA investment could be to facilitate the conversion of technologies developed in national 'centres of excellence' into products of value to meat producers and thus facilitate partnerships between researchers and the private sector.
- In this area issues of science quality and ability to deliver become critical as the development and marketing of these technologies is often international.

Generic Evaluation, Benchmarking and Genetic Gain Technologies

- Reviews over the past 20 years show that the situation in pastures lags behind that of the animal industries (regardless of personal/organisational opinions of exactly where things sit on the continuum).
- In this field issues of general applicability, access to a broad range of commercial players and education for the retail and producer sectors become important.

Potential use of the MLA Donor Company Model for Funding

- This vehicle has been used successfully for some technology and product development based projects in PBE in the past and at a preliminary glance it appears that some of the projects submitted may be more suitable for funding through this project than directly through the Feedbase program. Further comment/clarity on this issue should be sought from MLA during the review process.

Appendix C

PRODUCTIVE & SUSTAINABLE PASTURES

BACKGROUND NARRATIVE

Prepared by:
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Managing Director
SGA Solutions Pty. Ltd.

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1.0 Executive Summary

As the livestock industry re-emerges from the impact of the drought it together with the cropping industry is looking to re-establish the role of pastures both in terms of supporting the livestock feedbase necessary to meet future demands but also to reduce the economic risk and dependence on cropping and to provide a much needed break within the cropping rotation for disease and pest control.

To coincide with the re-emergence of the livestock and pasture industries the Federal and state governments (PISC) together with lead investment agencies within the beef and sheep meat industries have taken the opportunity to release a National R, D & E Strategy for the Beef and Sheep meat industries which will provide a platform for directing investment in the livestock meat industry, including investment in the feedbase.

As a flow on from the release of the national R, D & E strategies, Meat and Livestock Australia (MLA) as the principle agency responsible for investment into the feedbase which supports the livestock meat industry commissioned the development of a Feedbase Investment Plan (FIP) for the research, development and extension that underpins the southern Australian feedbase. The southern Australian feedbase is defined as herbage provided by pastures, grazing crops and shrubs from sown, naturalized and native plant species within the area south of the 26° line of latitude.

Subsequent to the release of the FIP, MLA has refined the areas of research areas into three investment platforms for future feedbase related R & D:

1. Plant breeding and evaluation,
2. Pasture agronomy & management (later changed to Productive & Sustainable Pastures), and
3. Grazing management & production systems.

Within the pasture agronomy and management platform the MLA FIP process identified two key R & D themes as potentially contributing the most significant impact on profit, productivity and sustainability of beef and sheep meat production from leading producers in southern Australia :

1) Soil Nutrition Balance for Productive Pastures: The report recommends that research address improvements in the efficiency, effectiveness and economics of fertilizer use by better testing and application regimes and better harnessing of soil biological processes. The key nutrient being phosphorus but attention to nitrogen, sulphur and potassium was also recommended.

2) Pasture Agronomy and Management for Productive Pastures: The report recommends that research be established to deliver information to allow management of pastures to fill feed gaps for increased persistence, quality and productivity in a variable climate.

A review of the key issues, trends and related research within each theme was undertaken and utilised as a platform for identifying key areas of research suitable for further evaluation and inclusion within future MLA investment in pasture agronomy and management research.

It is recommended that MLA invest in R & D project areas which are related to improving the efficient, effective and economic management of the soil nutrient base with an emphasis on the following areas of research:

i) Optimising and sustaining productivity and plant water use efficiency;

ii) Adoption of strategies that are environmentally benign;

iii) Recognising and minimising adverse soil processes, such as soil acidification; and

iv) Avoiding nutrient imbalances through evaluation and management.

v) Agronomic and environmental screening of exotic and native pasture plant species for increased persistence and which may be suitable for adoption in southern Australia.

vi) Genomic screening of plant species and organisms for persistence related traits and mechanism, including endophytes which are benign to the target pasture species, livestock and the environment.

vii) Physiological and morphological screening of current pasture species for selection and commercialization of "elite" lines which demonstrate superior levels of persistence.

It is recommended that the focus of MLA's pasture agronomy and management R & D be directed to projects that will contribute to the re-establishment and improvements to the productive capacity of the feedbase with an emphasis on the following areas of research:

i) Agronomic and environmental screening of exotic and native pasture plant species for increased persistence and which may be suitable for adoption in southern Australia.

ii) Genomic screening of plant species and organisms for persistence related traits and mechanism,

iii) Screening of endophytes which enhance perennial grass persistence and are benign to the target pasture species, livestock and the environment.

iv) Physiological and morphological screening of current pasture species for selection and commercialization of "elite" lines which demonstrate superior levels of persistence.

v) Enhancement of root morphology for more efficient nutrient up-take;

vi) Enhancement of legume root morphology for effective production of nitrogen;

vii) Enhancement of plant species tolerance to:

  a. root diseases and nematodes;

  b. environmental stress such as drought and frost;

  c. pest's such as aphids and earth mites.

viii) Alternate perennial/annual grasses, legumes, fodder crops and shrubs for improved:

  a. Pasture composition;

  b. Filling the summer feed gap;

ix) The establishment of a cost/benefit analysis focused on assessing the potential incremental gains in pasture and livestock management and productivity following the adoption of pasture monitoring tools and management programs.

x) The development and adoption of tools that will allow producers to monitor the performance of pastures and assist in the establishment of regular forage/pasture budgets to meet livestock requirements,

xi) The development and adoption of tools and processes that assist producers/service providers to increase pasture performance.

xii) The development of technologies/tools and the implementation of management strategies that will improve the persistence of key species and/or will reduce the risk of pasture decline.

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Authors Note:

In preparation of the narrative the following assumptions have been made with regard to its structure and output.

- That well adapted, productive pastures that are well managed and utilized are major drivers in reducing the cost of production for beef and lamb in southern Australia.
- That objective information is needed to describe the value of new pasture agronomy and management innovations for the feedbase in southern Australian livestock production systems.
- That new pasture agronomy and management innovations have the potential to provide both incremental and step-change improvements in productivity and profitability of the leading livestock meat producers.
- That there needs to be an increase in the number of: i) multiple public: public agency and ii) public: private collaborations and/or partnerships as these relationships will be critical to the success in generating investment and delivery of pasture agronomy and management innovations to leading livestock meat producers.
- That the outcomes of the process are directed towards the leading sheep meat and beef producers across the agro-ecological zones of southern Australia. For example, in relation to beef production the leading beef producers could be either i) the 27% of producers who represent 79% of the total beef herd in Australia[1] and /or ii) the top 20% of the most profitable beef producers in southern in Australia during the drought period 2004 – 2007[2].

[1] Primary Industries Standing Committee – R&D Sub-Committee 2010 , National Beef Production RD&E Strategy

[2] Holmes Sackett, 2009, Southern Beef Situation Analysis, MLA

2.0 Investments in Feedbase R, D & E 2000 - 2010

During the early part of the new millennium (2000 – 2010) investment in pasture agronomy and management research was directed towards activities such as fertilizer management, weed management, pasture establishment and to a limited extent the control of pests such as red-legged earth mite and lucerne flea.

The majority of investment emanated from the public sector via investment by state agencies and Rural Development Corporation (RDC's) such as MLA, GRDC and RIRDC via investment in R, D & E programs such as Pastures Australia, Enrich, EverGraze, Grain and Graze. The common objective of these programs was to develop the principles, tools and indicators for improving the profitability and sustainability of grazing systems across the agro-ecological diversity of southern Australia.

This fulfilled their role in the delivery of market failure research to livestock and pasture industry constituents. The private sector to a lesser extent supported pasture agronomy and management R & D primarily in areas where there was commercial incentive. (e.g. herbicides and insecticides for pest control, introduction of high analysis fertilizers)

During the latter part of the 2000 – 2010 period investment from the public and private sector into pasture agronomy and management R, D & E declined significantly as a result of the reduced revenues generated from industry levies and the loss of profitability in pasture related commercial activities within the supply chain.

Of the investment available for R, D & E the majority was redirected into activities which supported livestock producers manage the impacts of the drought on their short term viability. As a result often R, D & E investment was allocated to supporting livestock producers redirect their limited resources into areas such as managing smaller sheep flocks and beef cattle herds, managing changes to livestock enterprises and/or the conversion of long term areas of permanent pasture and/or native pasture to crops and/or annual pastures.

As a result of this need to support livestock producer viability during the period of the drought, the overall "productive capacity and health" of the on-farm feedbase pastures supporting livestock meat production across the majority of the agro-ecological zones of southern Australia declined during this period. The decline in both quality and quantity of pasture available for the feedbase was reflected in changes in:

- pasture type (e.g. < perennial pasture vs > annual pasture and fodder crops),
- changes in pasture composition (grasses vs legumes),
- loss of persistence in perennial pastures,
- increased impacts on pastures from both abiotic and biotic stress, and
- investment and activity associated with pasture rejuvenation and/or replacement.

A further consequence of the reduction in investment has been a decline in the level of expertise which exists within the respective public and private sectors to support R, D & E in pasture agronomy and management.

Following the vastly improved seasonal outlook for south eastern Australia during 2010 and into 2011, livestock producers are responding not only to the production and marketing opportunities that have been created but also to environmental and climate change issues such as biodiversity, landcare and soil salinity.

During the drought many producers were forced to change from their traditional medium – high input livestock enterprises (e.g. fertilizers, pasture renewal etc.) to a lower-input management regime that meant adopting strategies which included:

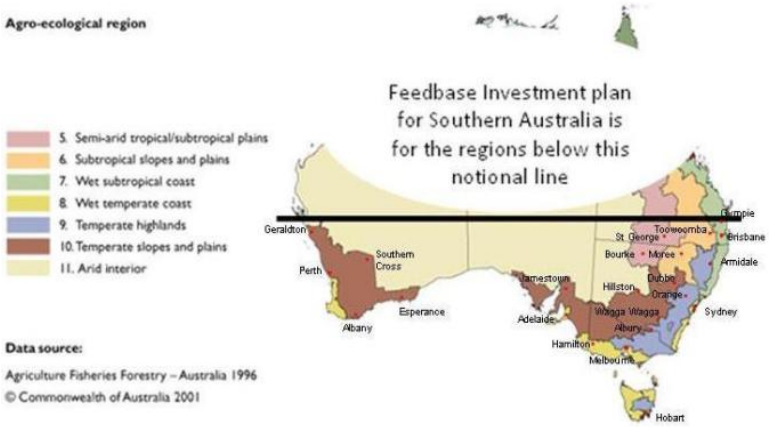
- reduced investment in fertiliser
- de-stocking,
- changes in livestock enterprise
- introducing crops within the farming system,
- reduced pasture renovation and sowing and
- greater attention to management strategies that maximised ground cover, and minimised environmental degradation.

With the apparent resurgence of the livestock meat industry in southern Australia there is an increasing recognition[3] that there needs to be re-investment back into R, D & E activities that are related to the feedbase and more specifically platform areas such as pasture agronomy and management.

[3] D. Hudson et al, 2009, Pastures Australia Review

3.0 Insights and Priorities from MLA and the FIP consultation

As a result of the increased awareness associated with the need to readdress R, D & E investment in the feedbase following the drought, in 2010, MLA Meat and Livestock Australia (MLA) commissioned the development of a Feedbase Investment Plan (FIP) for the research, development and extension that underpins the southern Australian feedbase. The southern Australian feedbase is defined as herbage provided by pastures, grazing crops and shrubs from sown, naturalised and native plant species within the area south of the 26° line of latitude.



The FIP process involved extensive industry consultation and has resulted in the identification of a number of research program areas that will lead to the development of new tools and technologies to better manage the pasture feedbase to improve profit, productivity and sustainability. In all, 15 areas for research were identified, the five most important were:

- Pasture utilisation/grazing management.
- Farming systems.
- Soil fertility.
- Improvement of legumes.
- Improvement of introduced perennial grasses.

Subsequent to the release of the FIP, MLA refined these areas of research into three platforms for MLA's R & D investment program:

1. Plant breeding and evaluation,
2. Pasture agronomy & management, and
3. Grazing management & production systems.

Within the Pasture Agronomy and Management platform a multiplicity of research areas were identified these include but were not limited to the following:

- Pasture utilisation/grazing management.
- Pasture persistence.
- Soil fertility.
- Soil biology
- Weed control
- Insect pest control

- Pasture utilisation/grazing management.
- Pasture establishment techniques.
- Decision support systems

Within the Pasture Agronomy and Management segment these research areas were collated into five theme's (Table 1) which form the framework and priorities for future MLA investment within this platform.

Table 1: MLA Pasture Agronomy and Management Sub-Programs

Pasture Agronomy and Management Theme's	
Pasture Health	Improved pasture nutrition through a combination of increased soil fertility, and/or fertiliser precision, and/or soil biological processes
Pasture Composition	Increased content of desirable species and increased consistency of legumes in pastures
Pasture Maintenance	Reduced incidence of and impact from, abiotic and biotic stresses in pastures.
Pasture Management	Pasture management tactics that improve pasture persistence, productivity and quality and that address feed gaps and seasonal variability.
Productive Pastures	Tools and processes to assist meat producers and service providers increase pasture performance.

The R & D priorities identified within the five Pasture Agronomy and Management themes are consistent with previous R & D reviews undertaken by MLA (Appendix Two).

While each of the themes are of themselves strategically important to pasture agronomy and management, due to the diversity and breadth of research related activities which the programs cover, these themes have been consolidated into two key themes which have the potential to contribute the most significant impact on the production of beef and sheep meat from leading livestock producers in southern Australia, these are:

1) Soil Nutrition Balance for Productive Pastures: Research that will address improvements in the efficiency, effectiveness and economics of managing soil nutrients by way of identifying the current nutrient status of soils supporting pasture production, identifying deficiencies and developing of management strategies to achieve a sustainable balance of nutrients within the soil that support livestock production.

   The key deliverables in relation to the theme of Soil Nutrient Balance R & D are:

   - Improved precision of determining the current soil nutrient status of pastures, identifying pasture/livestock requirements and where appropriate adopting application technologies to enhance the return from on-farm soil management and the use fertilizer applications; and
   - Greater understanding of the soil biology and plant root morphology and the role in managing the nutrients present in the soil. Leading to adoption of management strategies that are focused on the overall improvement in soil health as reflected in increased pasture productivity and persistence of pastures where soil nutrient balance is no longer a limiting factor to production.

2) Pasture Agronomy and Management for Productive Pastures: Research that will deliver information to allow management of pastures for increased composition, persistence and performance where soil nutrition is not a limiting factor.

The key deliverables in relation to the theme of Pasture Agronomy and Management R & D are:

- Integrated feedbase management systems including the role of forage crops and fodder conservation that fill feed gaps in traditional pasture systems and in emerging regions where pastures are being sought to replace crops within the mixed farming regions of southern Australia, including the role of forage crops and fodder conservation
- Management strategies to increase the composition and persistence of the legume component within pastures and thus contribute incremental soil nitrogen for pastures and crops.
- Management strategies that will address the short and/or long term impacts (either through prevention or treatment) resulting from abiotic and biotic stress on pasture feedbase components (i.e. permanent pasture, annual pasture and/or native pasture).
- Adoption of pasture monitoring tools and management programs that will lead to improvements in the utilization of pastures for livestock productivity.

4.0 Opportunities for MLA Research Investment in Pasture Agronomy and Management

4.1 Theme One: Soil Nutrient Balance for Productive Pastures

A wide range of pasture types provide the feedbase for beef and sheep meat production across southern Australia. There are three main pasture types, these are:

i. mainly native perennial grasses with some annual legume, e.g. sub-clover;

ii. annual grasses and legume based pastures;

iii. introduced exotic perennial grass pastures and annual or perennial legume.

The composition, persistence and performance of these pasture types is determined by a range of interactive factors which range from the ability of plant species to capture and compete with other plant species for resources such as soil nutrients, water and light through to the influence of temperature, soil, herbicide use for weed control and grazing management.

There are various plant physiological processes that determine a plant species to access and utilize soil nutrients. They include relative growth rate, internal nutrient requirements, mechanism's to conserve nutrients and root morphology.[4]

The two major groups of soil nutrients required to be present for optimum pasture composition, persistence and performance across the agro-ecological zones of southern Australia are:

- Macro-elements: Phosphorus (P), Sulphur (S), Nitrogen (N) and Potassium (K); and
- Micro-elements: Copper (Cu), Molybdenum (Mo) and Zinc (Zn).

Access to these soil nutrients is the major limiting factor for achieving optimum pasture composition, persistence and performance. The ability of pasture plants to access soil nutrients may be influenced by one or more of the following:

- Soils are inherently deficient in one or more nutrients.
- Nutrient imbalance limits the availability of one or more nutrients.
- Plants are unable to access nutrients due to physical or chemical barriers.
- One or more nutrients are present at toxic levels.
- Nutrients have been removed from the soil in the form of meat, milk, wool and grain and have not been replenished.

The majority of soils across the agro-ecological zones of southern Australia are inherently deficient in a number of key soil nutrients. The introduction of fertilizers (supplying adequate amounts of essential plant nutrients), soil ameliorants (e.g. lime, dolomite and gypsum that chemically and physically improve the soil) and the use of legumes to increase soil nitrogen status have had a profound impact in addressing and correcting the imbalance of these key macro and micro nutrients within soils. Especially, where the soil nutrient balance continues to change due to losses through either soil processes (e.g. leaching or immobilization) and/or through export of harvested products (e.g. meat, wool, grain and fodder).

[4] Hill JO, Simpson RJ, Wood J, Moore AD, Chapman DF. 2005. The phosphorus and nitrogen requirements of temperate pasture species and their influence on grassland botanical composition. *Australian Journal of Agricultural Research* 56(10) 1027–1039

During the 1980's and 1990's the introduction of products such as high analysis fertilizers and rhizobia for enhanced nitrogen fixation from legumes transformed and further sustained the productive capacity (I.e. pastures and livestock) of soils and pastures.

The impact of the historic commitment and investment in soil nutrient management during this period is reflected in a comprehensive survey of soils nutrients (Table 2) within agricultural soils (1989 - 1997). The findings of the survey were broadly grouped into two land use classes:

i) *the mixed cropping-livestock zone and*

ii) *the high rainfall or more intensive grazing zone*)

Table 2: Summary of the Farm Gate Nutrient Status of Six (6) Key Soil Nutrients Required for Pastures and Crops.

Nutrient	Land Use	WA	SA	Victoria	Tasmania	NSW	Queensland
Nitrogen	**Grazing**	+	+	Variable	=/+	=/+	-
	Crop	=/+	=/+	=/-	-	=/+	=/+
Phosphorus	**Grazing**	=/+	=/-	=/+	+	=/+	-
	Crop	=/+	=	=/-	+	+/=	-
Potassium	**Grazing**	-/+	-	-/=	+	=/-	-
	Crop	-	-	-	=	-	-
Sulphur	**Grazing**	+	+/=	+/=	+	+/=	-
	Crop	+/=	=/+	=/+	+	=/+	-/=
Calcium	**Grazing**	+	+	+	+	+	-
	Crop	+	=/+	+/=	+	+/=	-/=
Magnesium	**Grazing**	=	=	=/-	=	=	-
	Crop	-/=	-	-	=	-/=	-/=

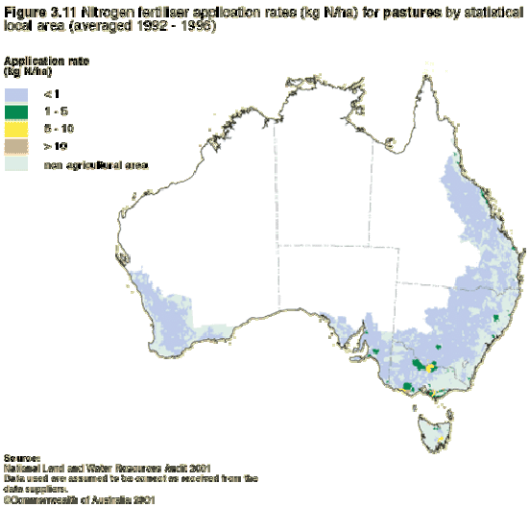
Neutral (=): Requires monitoring for change in status – current levels of soil nutrient adequate for crop and/or grazing.
Negative (-): Requires change to management including use of fertilizers and/or legumes to raise levels of nutrient.
Positive (+): Requires monitoring and no major change to management.

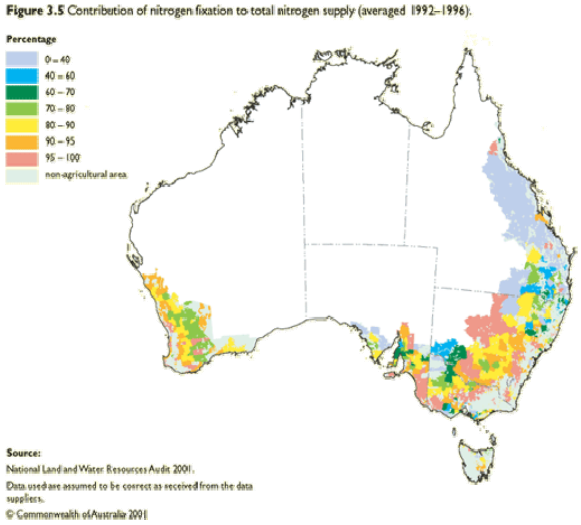
The study found that despite the historic use of fertilizers, soil ameliorants and legumes for managing and correcting soil nutrient balance there were marked spatial variations existing across agricultural regions.[5]
The key findings from the survey were as follows:

- Balances for nitrogen, phosphorus, sulfur and calcium varied from neutral (inputs = exports) through to positive (inputs > exports) in many regions, suggesting that supply is now approaching near-optimal levels, and soil nutrient reserves are not being mined.
- Nitrogenous fertilizer was used mainly on crops, sugar cane and in horticulture. Negligible amounts were applied to dryland pastures (Figure 3.11), but it was used on irrigated pastures, mainly for dairying and hay/silage production.

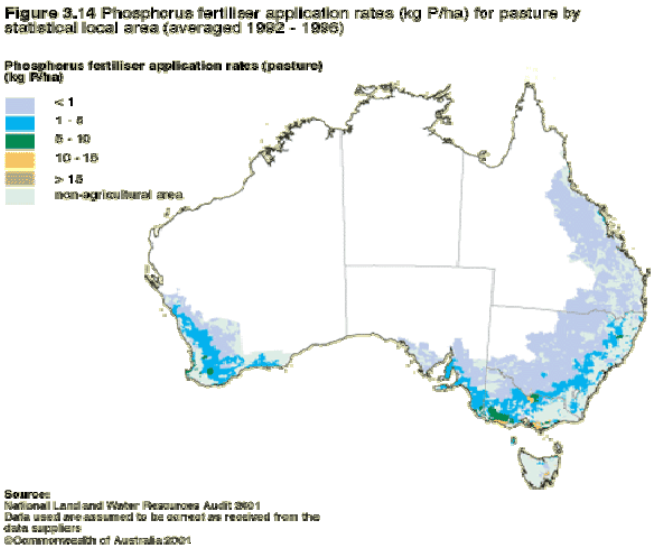
[5] Nutrient Balance in Regional Farming Systems and Soil Nutrient Status. National Land and Water Resources Audit. Final Report. September 2001

- Where legumes were grown, the average addition of nitrogen through atmospheric fixation was estimated to vary from <5 to >300 kg N/ha/year, with areas >100 kg N/ha being common. In southern Australian regions nitrogen fixation contributed over 60% of the total input of nitrogen (figure 3.5).





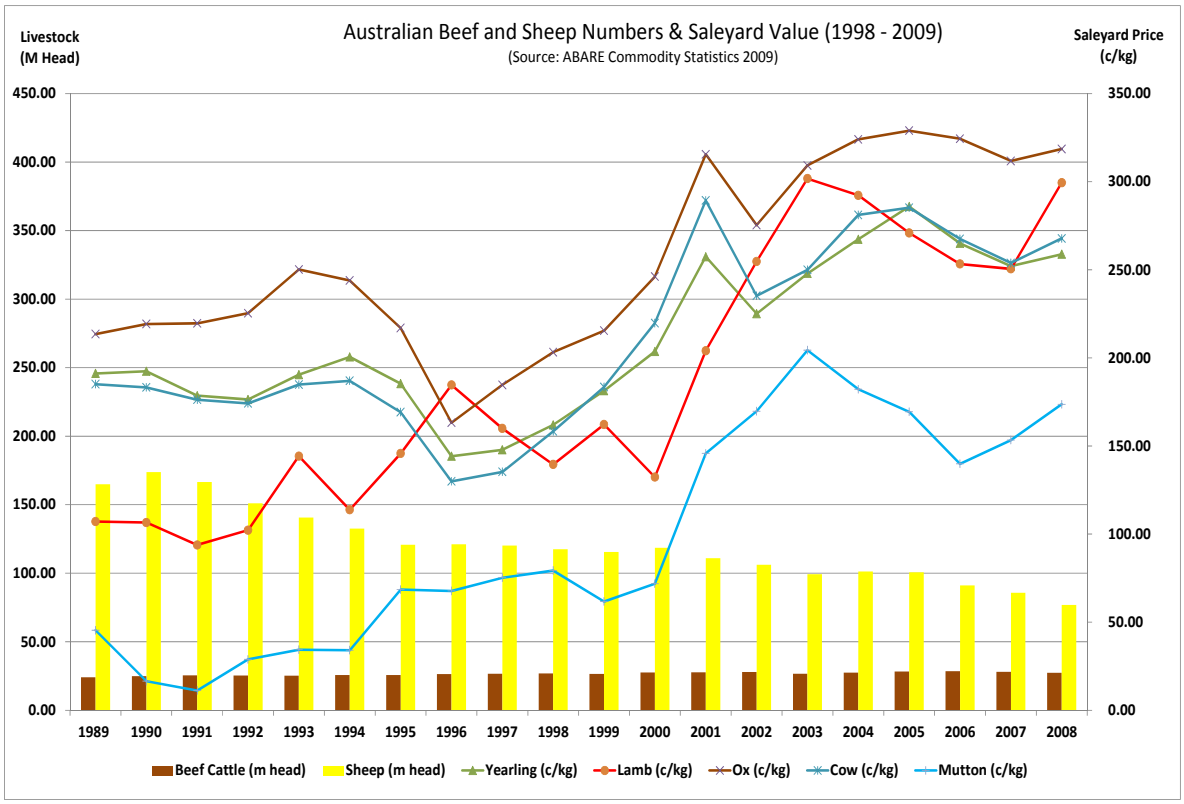
- Phosphorus applications appear to be directed to the cropping phases of rotations, with many pastures relying on residual soil phosphorus reserves (Figure 3.14). Phosphorus fertilizer use on dryland pastures is low (< 5 kg P/ha); by contrast it was higher on irrigated pastures.



- Potassium and magnesium balances were negative (inputs < exports) in most regions, but most Australian soils have good reserves, or potassium fertilizers are being applied where there are deficiencies.
- Negative balances, signifying soil nutrient depletion, existed in major regions of Queensland (all nutrients); the Victorian Wimmera (nitrogen, phosphorus and potassium); and parts of northern New South Wales and the Riverina (phosphorus). To gain a more precise spatial understanding of these findings, further regional scale investigations would be required.
- Highly positive balances often existed in regions where dairying and horticulture co-exist; suggesting improvements in the efficiency of nutrient use are required.

During the previous two decades Australian livestock producer's viability has been under extreme pressure due to a combination of increasing input costs, lower farm gate returns, declining livestock numbers (Chart One) and the impact of drought conditions in the mid 1990's and between 2001 and 2010 on pasture composition, persistence and performance.

Chart One: Australian Beef and Sheep Numbers and Saleyard Value (1989 – 2009)



The impact of declining pasture productivity through the loss of sown pasture species and degradation of the soil nutrient base was reported to be present even in more favoured environments with a long history of sown pastures, such as the south-west of Victoria, where wool production was reported as only achieving 46% of potential and only 5% of paddocks surveyed contained a minimum of 20% subterranean clover and 30% improved grasses.[6] Similar observations have been made for the species composition of sown pastures on the Central Tablelands[7], Southern Tablelands[8], Northern Tablelands[9] and the South West Slopes of New South Wales.[10]

[6] Schroder PM, Cayley JWD, Patterson AP, Quigley PE, Saul GR (1992) Achieving the potential of the pasture resource in southwest Victoria. In 'Proceedings of the 6th Australian Agronomy Conference'. (Eds KJ Hutchinson, PJ Vickery) pp. 154–156. (The Australian Society of Agronomy: Parkville, Vic.)

[7] Kemp DR, Dowling PM (1991) Species distribution within improved pastures over central NSW in relation to rainfall and altitude. *Australian Journal of Agricultural Research* **42**, 647–659.

[8] Munnich DJ, Simpson PC, Nicol HI (1991) A survey of native grasses in the Goulburn district and factors influencing their abundance. *Rangeland Journal* **13**, 118–129.

[9] Hutchinson KJ (1992) The grazing resource. In 'Proceedings of the 6th Australian Agronomy Conference'. (Eds KJ Hutchinson,PJ Vickery) pp. 54–60. (The Australian Society of Agronomy: Parkville, Vic.)

[10] Bowcher A, Virgona J (1997) Pasture composition survey of southern NSW. In 'Proceedings of the 12th Annual Conference of the Grassland Society of NSW'. (Eds A Bowman, D Michalk) p. 121. (The Grassland Society of NSW Inc.: Orange)

Within the permanent pasture regions of south-eastern Australia the surveys reported that the median legume content was only 5%. This is of concern given that it has been suggested that to achieve a positive nitrogen balance within the pasture legume content needs to be maintained between 20 and 45%.[11]

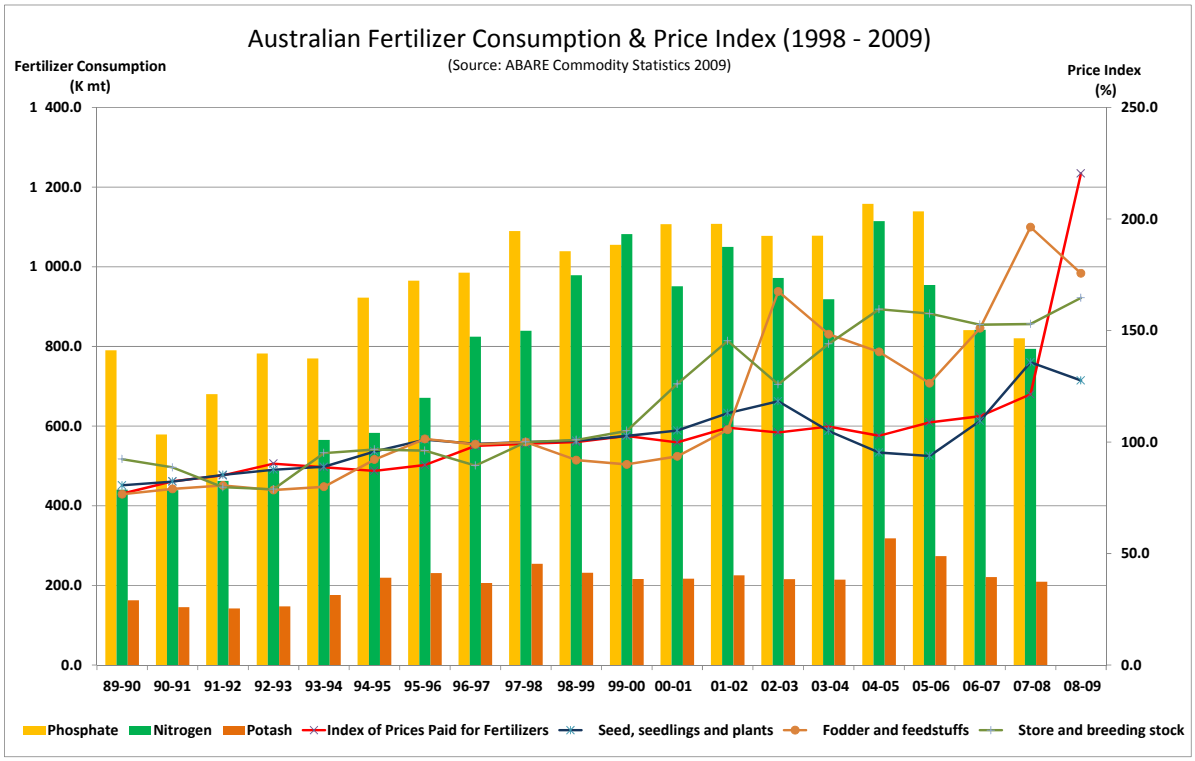
The decline in the legume component of the pasture feedbase within these regions is in part due to a combination of one or more of the following:

- the extended drought conditions reducing sward density and seed set,
- change from traditional subterranean clovers to more exotic poor persisting legume species,
- an increase in the presence of weed competition,
- the use of herbicides to control legume weeds in-crop, and
- the reduction of viable legume seed in the seed bank.

The decline in livestock enterprise viability and pasture productivity forced producers to either down size their grazing enterprises or diversify enterprise mix. The second of these options led many livestock producers to increase the proportion of crops within their farming operations and/or change the livestock enterprise/mix. In parallel livestock producers were forced to rationalize inputs or redirect resources (e.g. fertilizers) to the "best bet" options (i.e. livestock versus crops).

The decline in the use of fertilizers for maintenance of soil fertility for pastures was directly related to the declining livestock numbers, declining livestock returns (Chart One) and the rising cost of inputs related to pasture and livestock production, especially fertilizers (Chart Two).

Chart Two: Australian Fertilizer Consumption and Input Price Index (1989 – 2009)



[11] The role of the legume in the nitrogen cycle of productive and sustainable pastures. R. J. Thomas. Grass and Forage Science. Volume 47, Issue 32. Pages 133 – 142. June 1992

Anecdotal evidence would suggest that as a result of the decline in soil fertility and pasture composition during the previous decade there were significant impacts on key pasture and livestock performance indicators such as carrying capacity, joining weights, lambing percentages, branding percentages and turn off targets. Improved conditions throughout much of southern Australia since November 2009 has encouraged many producers to start rebuilding cattle herds and sheep flocks, either through a reduction in their turn-off of livestock for slaughter or via the purchase of breeding stock.

In order to meet the challenge of rebuilding livestock numbers following the drought livestock producers will need to refocus their management and resource investment into rebuilding their feedbase via the re-establishment of the soil nutrient balance requirements for their pastures. Within this process livestock producers will need to be cognizant of adopting management practices that are not on re-establishing nutrient balance within the soil but also it is achieved in a manner consistent with the principles of sustainable natural resource management (NRM) and the use practices which can lead to an increase in soil organic carbon and soil organic sequestration rates associated with these practices[12].

Soil organic carbon (SOC) is of fundamental importance to soil health and pasture productivity as it affects all three aspects of soil fertility, namely chemical, physical and biological fertility. The activity of living organisms in soil is dependent on regular inputs of organic matter.

Soil organic carbon sequestration refers to the storage of carbon in soil and is being considered as a strategy for mitigating climate change.

Soil organic carbon levels in soils supporting pastures are controlled by a range of factors, namely climate, soil, vegetation and time and can reach an equilibrium level under specific environmental conditions (environmental equilibrium). Over time, change in the storage of SOC is controlled by the balance between carbon inputs and losses (removal through mineralisation to carbon dioxide, and erosion). SOC levels in soils are very dependent on management practices that affect the inputs as well as removal of carbon materials, namely net primary production, quality of organic residues, residue management (e.g. burning, incorporation), soil management (e.g. tillage) and livestock management. In certain cases, additional SOC sequestration in excess of natural equilibrium level can also occur due to increased productivity as a result of removal of inherent soil constraints limiting plant growth.

In Australia, research has demonstrated that pasture improvement (such as sown pasture or fertiliser application) can lead to significant increases in SOC sequestration (500 kg C/ha/yr.)[13] compared to unimproved pasture. Long term trials in Australia have shown that this rate of SOC increase can be maintained for at least 40 years as a result of pasture improvement[14]. Other trials on improved pasture management treatments such as phosphorus and lime application have led to soil carbon sequestration at rates of 388-464 kg/ha/year between 1992 and 2005. It has been estimated that on the Southern Tablelands, many farmers still have 20-40% of their farms under unimproved native pasture and these pastures have the potential of substantial increases in SOC for many years if subjected to improved management practices[15].

[12] Scoping Paper: Soil Organic Carbon Sequestration Potential for Agriculture in NSW. KY Chan, A Cowie, G Kelly, Bhupinderpal Singh, P Slavich. NSWDPI Science and Technology Paper. Sept. 2008

[13] Gifford, RM, Cheney, NP, Noble, JC, Russel, JS, Wellington, AB, and Zammit, C 26 (1992). Australian land use, primary production of vegetation and carbon pools in relation to atmospheric carbon dioxide concentration. In RM Gifford and MM Barson (ed) Australia's renewable resources sustainability and global change, pp. 151-188, Bureaus of Rural Resources, CSIRO, Australia

[14] Russel, JS and Williams, CH (1982). Biochemical interactions of carbon, nitrogen, sulphur and phosphorus in Australian agroecosystems. In: Galbally, IE and Freney, JR (eds) "The Cycling of Carbon, Nitrogen, Sulphur and Phosphorus in Terrestrial and Aquatic Ecosystems". Australian Academy of Science, Canberra September 2006, Hunter Water Corporation

[15] Scoping Paper: Soil Organic Carbon Sequestration Potential for Agriculture in NSW. KY Chan, A Cowie, G Kelly, Bhupinderpal Singh, P Slavich. NSWDPI Science and Technology Paper. Sept. 2008

Management practices which can lead to an increase in soil organic carbon and soil carbon sequestration include i) the adoption of conservation tillage practices for pasture renovation and establishment, ii) implementation of erosion control systems, iii) zonal management of pastures, iv) efficient fertilizer management, v) pasture and grazing management budgeting, vi) the introduction of improved grass species, vii) increasing legume content, and ix) nitrogen fixation through the use of rhizobia.

A similar challenge to managing soil nutrient balance, NRM and soil organic carbon within pastures also fronted the Australian dairy industry. The dairy industry along with key stakeholders in government and the fertiliser industry have taken the initiative to develop a number of programs that contribute to improving the efficiency of nutrient use and minimise the likelihood of environmental losses to the environment. [16]

The need for a coordinated approach to improved nutrient management on dairy farms involving farmers, advisors, fertiliser companies and policy organisations has underpinned a strategic approach to this issue. Two key projects, 'Better Fertiliser Decisions' (2003-2007), and 'Accounting for Nutrients on Australian Dairy Farms' (2006- 2010), formed the basis of this approach. By engaging all these stakeholders, the relevance, rigour, and adoption of the information and tools arising from these projects will be maximised.

4.1.1 Implications for future MLA Investment

Given the current period of transition from the sustained drought conditions of the previous decade to increasingly stable agronomic, environmental and economic conditions soil nutrient research for increasing productivity of livestock meat producers in southern Australia will need to focus on outcomes which will rebuild sustainable and consistent nutrient balance in the soil and at the same time recognize increased community concerns about excess nutrients in water and the atmosphere.

This means that livestock producers will need to have access too, and use of information from R & D which optimise (i.e. efficiency, effectiveness and economic) soil nutrient management practices for environmental as well as productivity benefits.

Livestock producers will require from MLA investment in soil nutrient R & D which will deliver a more tailored approach to soil nutrient management. The outcome from delivery of the more tailored approach to soil nutrient management for pastures supporting livestock meat production will lead to:

- improvement in the management and efficiency in use of soil nutrients,
- increased efficiency and effectiveness in the use of resources required to maintain soil nutrient balance,
- reduce the risk of losses of soil nutrients to the environment, and
- either establishing and/or maintaining a more balanced, sustainable and persistent pasture feedbase.

In summary, MLA investment in soil nutrient management related R, D & E will need to focus on addressing the following:

- Optimising and sustaining productivity and plant water use efficiency;
- Adoption of strategies that are environmentally benign;
- Recognising and minimising adverse soil processes, such as soil acidification; and
- Avoiding nutrient imbalances through evaluation and management.

[16] Making Better Fertiliser Decisions for Grazed Pastures in Australia, Accounting for Nutrients and Fertcare®: Partnerships between Industry, Research and Government players. Cameron JP Gourley, KI Peverill and WJ Dougherty. Australian Fertilizer Industry Conference August 2007

4.2 Theme Two: Pasture Agronomy & Management for Productive Pastures - management of pastures for increased composition, persistence and performance for a variable climate and a diverse agro-ecological environment.

Pasture is the most efficient, effective and economic source of feed for all grazing-based livestock enterprises; growing more of it at the right times of the year can create opportunities for livestock producers to increase stocking rates, joining weights, livestock growth rates and reduce reliance on supplementary feeding. The focus for leading livestock producers is efficiently establish and managing the pasture sustainably for optimal livestock performance and to meet market requirement for products turned off the pasture.

The importance and benefits of efficiently growing and utilising pastures was demonstrated during the recent drought where the top 20% of profitable specialist beef producers in southern Australia delivered higher productivity (kg beef /ha) by way of more efficient use of their resources, primarily by continually managing and matching their pasture productivity to their stocking rates.[17]

The productivity and profitability of many grazing enterprises across the agro-ecological zones of southern Australia can be greatly improved by increasing and maintaining the composition and persistence of the pasture species established and applying management strategies that enhance utilization of the pasture available.

The quantity and quality of pasture available underpins strategic decisions such as time of joining, time of lambing/calving, flock/herd structure, stocking rates and delivery of livestock into target markets. The health and fertility of the soil and stage of growth at which pasture is grazed therefore has a major effect on pasture growth and quality.[18]

Pasture agronomy and management is the process of establishing pasture persistence, maintaining pasture productivity and making better use of the pasture in order to meet the objectives of the livestock enterprise.

4.2.1 Pasture Persistence

Increasing stocking rate per ha is a powerful method by which graziers can lift productivity. Even when this is done in concert with measures to increase the feedbase (e.g. pasture renovation, increased soil fertility), persistence of key pasture species (e.g. perennial grasses) often suffers under high grazing pressure. In addition the significantly lower annual rainfall experienced across southern Australia over the past decade together with projections of long term climate change have placed increased emphasis on the use of pasture species and varieties with superior tolerance to environmental stress, particularly drought, to ensure persistence for the grazing industries.

Pasture persistence is a concept describing the net balance between production and loss of a species/cultivar through either vegetative processes, e.g. tillering of grass and stolon branching of legume, or reproductive process, i.e. natural reseeding, or both[19]. A persistent species is one with a stable or increasing net balance between production and loss over the long term. A species with a declining balance is poor in persistence.

The longevity of a pasture sward following establishment directly impacts on the level of profit and gross margins achieved and constrains the opportunities for productivity gains. Loss of perennial species also has adverse consequences for natural resource management (NRM) outcomes (soil acidification, nutrient loss, soil loss, etc.).

[17] Holmes Sackett, 2009, Southern Beef Situation Analysis, MLA

[18] Grow More Pasture, Module 7, Making More from Sheep, MLA

[19] Nie, Z.N., D.F. Chapman, J. Tharmaraj, and R. Clements. 2004b. Effects of pasture species mixture, management and environment on the productivity and persistence of dairy pastures in south west Victoria. 2. Plant population density and persistence. Aust. J. Agric. Res. 55:637-643.

The major influence on the ability of a pasture to sustain profitability is the management of stocking rates both in the early years following establishment and through periods of "off peak" production, whether that be caused by seasonal decline in production (i.e. summer) or by the impact of events such as abiotic stress (e.g. drought, flooding, frost, salinity, soil fertility, soil acidity) and biotic stress (e.g. insects, disease, grazing pressure). High stocking rates on new sown pastures increases short term profits, but also decreases pasture persistence and increases economic risk. The net result is reduced long term profit, more risk and less persistent pastures.[20]

Persistence issues are addressed currently by a variety of approaches that reflect current knowledge and the nature of the persistence issues in each agro-ecological region. For example, persistence has long been recognised as a constraint in phalaris-based pastures which are sown with the intention of running more livestock.

The issue of pasture persistence has emerged with the introduction of winter-active phalaris cultivars that supported higher production per hectare, but were soon recognised as less persistent than the original varieties. Persistence issues were associated with acid soils, low soil fertility and grazing pressure. Solutions have mainly addressed these issues directly (lime-application, fertiliser use, rotational grazing), but a major breakthrough has been achieved with the breeding and current release of a grazing-tolerant cultivar (Holdfast GT) that now combines the persistence of the benchmark cultivar (Australian) and the productivity of the winter-active genotypes. Phalaris with exceptional acid-soil resistance has also now been bred. However, this cultivar (Advanced AT) is released with a strict recommendation concerning the need for rotational grazing and demonstrates the importance of linking breeding solutions with agronomic management.

Another innovation in relation to persistence of pastures in south eastern Australia has been the introduction of endophyte technology in perennial ryegrass and tall fescue. Fungal endophytes live in the tissues of many plants, including many grasses. Over the last 20 years, the endophyte (Neotyphodium lolii) that infects perennial ryegrass has become central to New Zealand's livestock production systems and increasingly becoming a key component of Australia livestock production systems in the medium to high rainfall zones where perennial ryegrass can persist.

The endophytic association with pasture grasses is a finely balanced interrelationship whereby each partner is adapted precisely to the other. The relationships are critical for the plants' protection against insect pests and assist pasture persistence but they are also responsible for debilitating animal diseases.

Research is currently focused on sequencing of an endophyte genome with the objective of understanding how genetics controls the production of the chemical compounds by endophytes so that it is possible to develop new variants that deter pests but do not harm livestock.

Plant persistence is also a significant issue in pasture systems based on native grasses where high-tech breeding solutions are not available. There is a relatively poor understanding of the ecophysiology of persistence problems of native grasses, the extent to which these systems should be fertilised and stocked is ill-defined and the efficacy of grazing management solutions is poorly understood.

4.2.1.1 Implications for future MLA Investment

Given the number of contributing factors to the loss of persistence within a pasture the resolution to increasing the persistence of pastures requires a multifaceted approach to research investment. Examples of key areas of research investment may include, but not be limited to the following:

- Agronomic and environmental screening of exotic and native pasture plant species for increased persistence and which may be suitable for adoption in southern Australia.

[20] K. Behrendt, O. Cacho and J. Scott. 2006. The Cicerone Project Inc. and the Centre for Sustainable Farming Systems

- Genomic screening of plant species and organisms for persistence related traits and mechanism, including endophytes which are benign to the target pasture species, livestock and the environment.
- Physiological and morphological screening of current pasture species for selection and commercialization of “elite” lines which demonstrate superior levels of persistence.

4.2.2 Maintaining Pasture Productivity

Optimal pasture productivity is related to the qualities of the main grasses in the pasture sward, their drought tolerance, winter-activity and yield potential, and is strongly influenced by pasture legume content, with higher legume composition occurring in pastures with optimum nutrition and management.

Within southern Australia addressing the establishment and maintenance of pasture productivity via the use of annual/perennial grasses and legumes is complex as the selection of pasture species is governed by a combination the agro-ecological environment, climatic conditions and the livestock enterprise/’s demand for pasture (e.g. permanent pasture vs. mixed farming).

Since the early 1990s a number of sustainability and economic challenges to existing livestock enterprises and farming systems have emerged leading to the view that legume-based pastures are declining in productivity[21] [22]. A pasture survey in southwest Victoria revealed that the majority of pastures were dominated by low-producing, “unimproved” grass species[23] . Similar results were also found in southern New South Wales[24]. In a survey of graziers in the high rainfall (>600 mm) temperate pasture zone of south-east Australia[25], 82% of respondents indicated that pastures weakened and disappeared within 10 years of sowing. In the Tamworth district of northern New South Wales, 73% of respondents reported an average life of a sown pasture of less than 5 years.

Previous surveys concluded that pasture decline manifested as an increase in weeds and a decrease in pasture legumes as well as fewer grasses and perennials, and that this change in botanical composition resulted in less vigorous pastures and lower productivity[26] and exposing shortcomings in the traditional species and a lack of legume biodiversity.[27]

There are number of factors which in isolation or in combination continue to contribute to pastures failing to achieve their productive potential, these include:

- Loss of legume content within the pasture sward;
- Spatial competition for resources with weeds and other pasture species;

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[21] D.T. Vere. 1998 Investigating improved pasture productivity change on the New South Wales tablelands Agricultural Economics Volume 18, Issue 1, January 1998, Pages 63-74

[22] Carter ED Wolfe EC Francis CM 1982. Problems of maintaining pastures in the cereal-livestock areas of southern Australia. *Proceedings of the 2nd Australian Agronomy Conference Wagga*, 68-82.

[23] Quigley, P.E., G.N. Ward, and T. Morgan. 1992. Botanical composition of pasture in south-western Victoria. *In* Proc. 6th Australian Society Agronomy Conf. Armidale, NSW, Australia.

[24] Virgona, J., and S. Hildebrand. 2007. Biodiversity and sown pastures: What you sow is not what you get. p. 33-39. *In* Proc. 48th Annual Conf. Grassl. Soc. Southern Australia.

[25] Reeve IJ, Kaine G, Lees JW, Barclay E (2000) Producer perceptions of pasture decline and grazing management. *Australian Journal of Experimental Agriculture* 40, 331–341.

[26] Reeve IJ Kaine G Lees JW Barclay E 2000. Producer perceptions of pasture decline and grazing management. *Australian Journal of Experimental Agriculture* 40, 331-341.

[27] Effects of pasture management on germinable seed bank in a degraded phalaris pasture. Jim Virgona and Annabel Bowcher. "Agronomy, growing a greener future?". Edited by DL Michalk and JE Pratley. Proceedings of the 9th Australian Agronomy Conference, 20-23 July 1998, Charles Sturt University, Wagga Wagga, NSW.

- Constraints to nutrient uptake;
- Constraints to root development, including root diseases and nematodes;
- Constraints to foliar development, including insects;
- Abiotic stress tolerance – drought, frost, water logging etc;
- Soil fertility issues (previously addressed);

Of these factors maintaining sufficient legume component within the pasture sward has been viewed as the most significant limitation to the recovery and sustainable productivity of pastures across southern Australia.

In southern Australia, pastures based on annual and perennial legumes have long formed an integral part of mixed farming enterprises. The legume pastures provide quality pasture for grazing animal's, boosts soil (N) fertility and are also used to disrupt disease and pest cycles in ley-farming systems.

The current decline in the presence of adequate levels of legume species to maintain productivity within pastures is in part due to a combination of one or more of the following:

- the extended drought conditions reducing sward density and seed set,
- change from traditional subterranean clovers to more exotic poor persisting legume species,
- an increase in the presence of weed competition,
- the use of herbicides to control legume weeds in-crop, and
- the reduction of viable legume seed in the seed bank.

As with the decline in the presence of legumes within the pasture sward there have been increasing concerns with the ability of perennial grasses to maintain productivity within a pasture sward. Of the four perennial grasses (ryegrass, phalaris, tall fescue, and cocksfoot) most commonly sown in temperate Australia, perennial ryegrass is widely used in the higher and more reliable rainfall areas or under irrigation because of its fast establishment, high growth rate, and good feed value.[28] However, the capacity of perennial ryegrass to maintain productivity is often poor on certain soil types and under drought stress even in relatively high rainfall environments.

In recent studies comparing series of perennial and short-lived ryegrass mixtures, using both old, allegedly more persistent and newer cultivars of perennial ryegrass, with a mix of tall fescue, phalaris and cocksfoot (triple mix) all of the ryegrass-based pasture types declined to an average of 62% of their establishment tiller densities by year 3, and 55% by year 4. However, in years 3 and 4, the triple mix remained similar to its establishment tiller density.[29]

Whereas phalaris, tall fescue, and cocksfoot are generally more drought tolerant than perennial ryegrass, they have limitations in persistence on different soil types. Phalaris is superior on heavy textured fertile soils or those with a distinct A2 horizon.[30]

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[28] Waller, R.A., and P.W.G. Sale. 2001. Persistence and productivity of perennial ryegrass in sheep pastures in south-western Victoria: A review. Aust. J. Exp. Agric. 41:117-144.

[29] Nie, Z.N., D.F. Chapman, J. Tharmaraj, and R. Clements. 2004b. Effects of pasture species mixture, management and environment on the productivity and persistence of dairy pastures in south west Victoria. 2. Plant population density and persistence. Aust. J. Agric. Res. 55:637-643.

[30] Myers, L.F., L.J. Hamilton, and J.R. Sleeman. 1985. Adaptation of temperate perennial pasture grasses to specific soils in north-east Victoria. p. 99-101. *In* J.L. Wheeler et al. (ed.) Temperate pastures – Their production, use and management. Australian Wool Corporation and CSIRO, Melbourne, Australia.

Cocksfoot is persistent on acidic, light-textured soils but intolerant of waterlogging.[31] Tall fescue grows better on medium to heavy textured soils and is more tolerant of heat stress than cocksfoot.[32] [33]

Apart from changes to the composition of pastures, pasture productivity can also be impacted from time to time by weed invasion and pests that consume pasture and damage the plants. For example Red legged earth mite (RLEM) has been identified as the priority pasture pest for research and control within the sheep industry. RLEM are destructive pasture pests estimated to cost Australian livestock producers around $200 million per year in lost production. RLEM are found throughout livestock production areas of southern Australia where the climatic conditions are dominated by winter rainfall and dry summers. In 2001-2002 the impact of weeds on pasture productivity for the Australian beef and sheep meat and wool producers was estimated to be costing between $475 million to $524 million in weed control costs and approximately $1.5 billion in lost production.[34]

While the impact of insects and weeds on pasture productivity has been minimal during the extended drought period of 2001 – 2010 there are concerns that following the recent change to favourable environmental conditions for the rejuvenation of pastures there may be a parallel re-emergence of weeds and damaging pests within the pastures swards of southern Australia.

4.2.2.1 Implications for future MLA Investment

The Future Farming Industries CRC (http://www.futurefarmcrc.com.au) is now the major vehicle for research investment into research addressing factors that limit the productive potential and capacity of pastures in southern Australia. Specific areas of research include the following:

1. The *Improved Perennial Grasses* project is evaluating recently bred temperate perennial grass cultivars for areas currently marginal for perennial grasses on the inland slopes of the Great Dividing Range in Victoria and New South Wales. It builds upon the work done by CRC Salinity and CSIRO to create new cultivars of cocksfoot, tall fescue and phalaris tolerant of low rainfall, prolonged summer drought and soils with high acidity and high aluminium levels. The new cultivars will be water efficient, making them suitable complements to lucerne in phase farming systems in relevant regions and more reliable in drier climate scenarios.

   A critical part of this project will be the development of optimum grazing management practices for these new cultivars to be delivered as agronomy extension packages.

2. The *Enrich Phase 2* project is developing profitable shrub-based systems that best utilise the interactions between soil, plant performance, phytochemistry, animal grazing behaviour, animal nutrition and gut health. The project is exploring the use of alternative forage shrubs and, in particular, how they can add to the existing feed base. The CRC believes improvements can be made by

   a. Using a greater range of shrub species

   b. Using complementary plant species (including herbaceous species with shrubs)

   c. Manipulating learnt behaviour and training animals to improve shrub utilisation

[31] Reed, K.F.M. 1996. Improving the adaptation of perennial ryegrass, tall fescue, phalaris, and cocksfoot for Australia. N.Z. J. Agric. Res. 39:457-464.

[32] Hoveland, C.S., E.M. Evans, and D.A. Mays. 1970. Cool season perennial grass species for forage in Alabama. Alabama Agric. Exp. Sta. Bull. No. 397. Auburn University, Auburn, AL.

[33] Reed, K.F.M. 2006. Species and cultivars for improved pastures. p. 20-33. *In* Z.N. Nie and G. Saul (ed.) Greener pastures for south west Victoria. Victorian Department of Primary Industries, Hamilton, Australia.

[34] The Economic Impact of Weeds on Australian Agriculture. Report to the CRC for Australian Weed Management By: Jack Sindenab, Randall Jonesbc, Susie Hesterba, Doreen Odomba, Cheryl Kalischda, Rosemary Jamese and Oscar Cachoab. February 2004

d. Capitalising on of plants to provide nutrients and beneficial secondary compounds for grazing livestock, as profitable and sustainable components of mixed enterprise farms.

3. The *Oldman Saltbush Improvement* project will expand the use of Oldman saltbush through breeding programs targeted at releasing cultivars for livestock grazing with improved nutritional value, palatability and biomass production. The project utilises comprehensive germplasm collections established in NSW, WA and SA where initial measurements demonstrate substantial variability in plant growth, palatability and nutritional characteristics. The long term aim is to release clonally propagated cultivars suitable for saline and non-saline soils and establish seed orchards for ongoing breeding of improved seed lines.
4. The *Productive, Persistent Tropical Grasses* project will develop and commercially release new tropical grass varieties for the south coast and the northern agricultural areas of WA and northern NSW. This includes the selection and release of a new *Panicum maximum* variety following evaluation under grazing in two key target environments.
5. The *Lotus Commercialisation* project is commercialising five lotus cultivars developed during the FFI CRC's predecessor the Salinity CRC. In that project (Lotus Breeding) only elite lines were to be produced for national evaluation however the project team exceeded expectations by producing five new cultivars. The four Lotus corniculatus cultivars produced are targeted at areas receiving more than 600 mm of a.a.r where the soils are too acid for lucerne and the summer drought is too harsh for white clover. The Lotus australis cultivar is a sub-shrub suited to areas of low rainfall (<400 mm) and neutral to alkaline soils.
6. The *Establishment of Perennial Pastures* project is focused on researching and developing a suite of reliable, robust and economical establishment pasture species for the most promising salt land, native and warm season perennial species for recharge, discharge and pastoral areas of southern Australia.
7. The *Enhance* project is assessing the nutritive value of saltbush and the potential to manage the behaviour of an animal's voluntary intake of the plant to better define saltbush grazing benefits. Planting saltbush on mildly saline land leads to greater whole farm profitability, increased livestock carrying capacity in autumn and a range of environmental benefits. The unique attributes for saltbush, which make it the standout option for managing non-waterlogged saline land, include its capacity to provide limiting nutrients for animals, but this has been inadequately explored whilst attention has been on defining its contribution of digestible energy and salt to livestock

Despite the diversity in research being undertaken by the FFI CRC and that undertaken within private and public sector pasture breeding programs (refer PBE platform) there remains a "gap" in complimentary abiotic and biotic stress related research that continues to limit the productive potential of pastures across southern Australia.

These areas of research include, but are not limited to the following:

- Enhancement of root morphology for more efficient nutrient up-take;
- Enhancement of legume root morphology for effective production of nitrogen;
- Enhancement of plant species tolerance to:
    - root diseases and nematodes;
    - environmental stress such as drought and frost;
    - pests such as aphids and earth mites.

In addition traditional areas of research that require continued investment for enhancement of pasture productivity include:

- Alternate perennial/annual grasses, legumes, fodder crops and shrubs for improved:
    - Pasture composition;
    - Filling the summer feed gap;

4.2.3 Better Pasture Use – Tools for Enhancing Pasture and Livestock Management.

The productivity of beef cattle and sheep is largely governed by the quantity, quality (i.e. nutritive value) and presentation of the pasture species present within the pasture sward and the application of livestock management strategies (refer to PMS Platform) to effectively utilize the pasture.

Underpinning the management strategies to effectively utilize the pasture is the quality of the pasture which is a reflection of two main characteristics of the pasture sward present:

1. The proportion of legumes and pasture grass species in the pasture sward.
2. The digestibility, protein content, digestible fibre content of the pasture present.

There has been significant investment by both the public and private sector primarily through breeding program development into establishing the initial nutritive quality of various commercial and native pasture species which are utilised by livestock producers within their respective livestock enterprise types.

Due to the diversity of environments, climatic conditions and livestock enterprises into which pasture species are sown little is known of the nutritive quality of pastures once the pasture has been established. Once established the traditional approach to assessment of nutritive value of pastures (including soil nutrient status) has been by visual assessment combined with "local knowledge and experience".

The first major change to this traditional approach to agronomy and pasture management occurred with the introduction of "easy to use" soil tests during the mid 1970's, followed by the introduction of leaf tissue testing in the mid 1980's. Livestock producers were able to move from blanket district recommendations for fertilizer use and application to localised management decisions within the paddock. However, with each test livestock producers were dependent on "off-farm" testing which was both time consuming, expensive and restricted their ability to make timely management decisions.

During the previous two decades the increasing impact of declining livestock returns, rising input costs, the influence of unfavourable climatic conditions and increased awareness of the need for more efficient and effective environmentally sustainable natural resource management raised the interest in the use of "tools" to monitor pasture productivity and assist in management of soils, pastures and livestock.

Tools that would assist in measuring and mapping pasture mass have the potential to offer livestock producers information of the current condition of their pasture that can be used for implementing timely and spatially-efficient management strategies relevant to managing grazing livestock, such as choice of stocking rate, rotation frequency and site specific fertiliser management[35].

[35] Bell AK, Allan CJ (2000) PROGRAZE – an extension package in grazing and pasture management. *Australian Journal of Experimental Agriculture* 40, 325–330

The need to develop and introduce these tools is reinforced by the ABARE *Meat & Livestock Australia management practices survey 2007-08* which demonstrated that despite the severity of the drought on pasture and livestock production the majority of livestock meat producers, including the "top producers" across southern Australia were monitoring their pastures and undertaking forage/pasture budgeting. (Table 3)

Table 3: Frequency of Forage/Pasture Budgeting, ABARE *Meat & Livestock Australia management practices survey 2007-08.*

Frequency of Forage/Pasture Budgeting	Sheep Enterprises			Specialist Beef Producers Southern Australia			Mixed Enterprises Southern Australia		
	Bottom Third * (%)	Middle Third * (%)	Top Third * (%)	Bottom Third (%)	Middle Third (%)	Top Third (%)	Bottom Third (%)	Middle Third (%)	Top Third (%)
Weekly	30	40	23	6	32	20	49	29	30
Monthly	19	14	28	11	12	15	10	19	19
Quarterly - Biannual	8	5	14	25	21	12	10	14	13
Annual	23	9	8	26	5	6	10	7	11
Never	20	33	28	32	30	47	22	33	27

N.b. Defined as the ratio of farm business profit to opening capital.

In response to this increasing demand for tools to assist in pasture and livestock management decision making a range of pasture evaluation tools and pasture monitoring protocols such as PROGRAZE[36] and pasture-livestock models such as GrassGro[37] and DairyMod[38] were assembled and used to monitor progress and set targets in Australian pasture-livestock enterprises.

The range of pasture monitoring tools which have been introduced for pasture assessment and analysis has ranged from direct measurements of pasture herbage mass have traditionally involved harvesting, sorting and weighing of samples from numerous, relatively small quadrats through to vehicle mounted optical sensors and satellite imaging.

Numerous groups have investigated the relative performance of the different methods with respect to the information collected which has ranged from pasture parameters such as cover (%), botanical composition (%), biomass (kg/ha), growth (kg/ha/day) and plant populations (numbers/m^2) through the protein content, dry matter and digestibility.[39] [40]

[36] Bell, A.K. & Allan, C.J. (2000) PROGRAZE – an extension package in grazing and pasture management. *Australian Journal of Experimental Agriculture* 40, 325-330.

[37] Clark, S.G., Donnelly, J.R. & Moore, A.D. (2000) The GrassGro decision support tool: its effectiveness in simulating pasture and animal production and value in determining research priorities. *Australian Journal of Experimental Agriculture,* 40, 247-256.

[38] Johnson, I.R., Chapman, D.F., Snow, V.O., Eckard, R.J., Parsons, A.J., Lambert, M.G. & Cullen, B.R. (2007) DairyMod and EcoMod: biophysical pasture-simulation models for Australia and New Zealand. *Australian Journal of Experimental Agriculture*, 48, 621-631.

[39] Wolfe, E.C., Paul, J.A. & Cregan, P.D. (2006) Monitoring ley pastures and their response to winter cleaning. *Australian Journal of Experimental Agriculture*, 46, 1023-1033.

[40] M. G. Trotter et al(2010). Evaluating an active optical sensor for quantifying and mapping green herbage mass and growth in a perennial grass pasture. Crop & Pasture Science, 2010, 61, 389–398

4.2.3.1 Implications for future MLA investment

While the benefits of monitoring and utilising management tools such as pasture plates and pasture production models have been well documented for intensively managed dairy pastures[41] there has been little evidence of the extent of adoption and the benefits of this approach to the extensive management of livestock producers.

Prior to investment in these "tools" an objective cost-benefit analysis is required to be undertaken which focuses on evaluating what technologies are available in terms of the extent of their current use, strengths/weaknesses/opportunities/threats, cost of market entry/access and impact on pasture and livestock performance.

If deemed appropriate following the completion of the cost-benefit analysis key areas of research may include:

- The development and adoption of tools that will allow producers to monitor the performance of pastures and assist in the establishment of regular forage/pasture budgets to meet livestock requirements.
- The development and adoption of tools and processes that assist producers/service providers to increase pasture performance.
- The development of technologies/tools and the implementation of management strategies that will improve the persistence of key species and/or will reduce the risk of pasture decline.

[41] Fulkerson WJ, McKean K, Nandra KS, Barchia IM (2005) Benefits of accurately allocating feed on a daily basis to dairy cows grazing pasture. *Australian Journal of Experimental Agriculture* **45**, 331–336. doi:10.1071/EA03109

5.0 The impact of previous investment in pasture agronomy and management R & D

Since 2002, Meat and Livestock Australia (MLA) has undertaken a number of extensive reviews relating to its investment in feedbase related R & D and the adoption of outcomes from its feedbase R & D investments by way of its various producer targeted extension programs. (Appendix One) The reviews together with a number of industry strategy documents have formed a significant platform on which MLA plans its future R & D direction and investment.

In recent years the leading programs for MLA investment for extension of its pasture agronomy and management R & D have been "More Beef from Pastures" and Making More from Sheep". The outcomes of these programs provide an indication as to the level of impact that has been achieved by livestock producers adopting outcomes from MLA's pasture agronomy and management R & D. (Table 4)

Table 4: Results achieved from MLA investment in More Beef from Pastures" and "Making More from Sheep"[42]

More from Beef From Pastures	• During 2009, 50% of program participants have implemented management changes.
	• In 2009, 59% of participants completed the "Pasture Growth" module and 64% completed the "Pasture Utilization" module.
	• Components leading to property improvements:
	  • Increased pasture ground cover - 54%
	  • Improvement in soil fertility & health – 34%
	  • Improved grazing management – 59%
	  • Improved pasture species – 25%
	  • Improved fertilizer application – 21%
	  • Integrated pest and weed management – 23 %
	• Components leading to production improvements
	  • Pasture and grazing management – 71%
	  • Soil management – 13 %
	• Components resulting in profitability improvements:
	  • Pasture & grazing management – 30%

Making More from Sheep	• During 2009, 57% of participants implemented management changes.
	• In 2009, 73% of participants completed the "Grow More Pastures" module and 54% completed the "Turn Pastures into Product" module.
	• Components leading to property improvements:
	  • Increased pasture ground cover - 37%
	  • Improvement in soil fertility & health – 18%
	  • Improved grazing management – 56%
	  • Improved pasture species – 19%
	  • Improved fertilizer application – 11%
	  • Integrated pest and weed management – 9%
	• Components resulting in production improvements:
	  • Health & Nutrition – 27%
	  • Pasture management – 8 %
	• Components resulting in profitability improvements:
	  • Pasture management – 35%

[42] GHD Hassall, 2009, Report for External Review of MBfP and MMfS Programs.

While the outcomes of the "More Beef from Pastures" and Making More from Sheep" review assist in identifying the level of success they also identify the key areas of pasture agronomy and management which are of importance to the livestock producers participating in the programs. However, the results are unable to identify those topics which are of significance to the leading livestock producers. (i.e. 80:20 rule).

In addition to the assessment provided by analysis of the MLA extension programs additional insight into the adoption and impact of MLA's investment in R & D can be gauged from the ABARE Management Practices Survey's undertaken in 2005/06[43] and 2007/08[44], For example in the 2007/08 survey it was noted by the author's that there were significant differences between the top one-third of producers ranked by rate of return to capital and the bottom one-third of producers in their use of a range of management practices and technologies.

The ABARE survey went to suggest that there had been an increase in adoption by specialist beef and mixed enterprise producers in southern Australia of pasture and grazing management practices. ABARE also reported that there was a corresponding reduction in the proportion of producers who never calculated a forage or pasture budget between the 2005/06 and 2007/08 surveys.

By contrast the ABARE survey demonstrated that there had been a decline in the percentage of sheep, mixed enterprise and specialist beef producers in southern Australia in their use of i) setting pasture utilization target when adjusting stocking rates and ii) the routine assessment of the digestibility of the feedbase available for livestock production. For those southern producers with a documented farm plan in 2007-08, 70 per cent included a weed management strategy, which was more likely to be incorporated in the plans of the better performing farms.

Despite the success of the MLA supported R, D & E programs in achieving positive outcomes for participants in relation to the adoption of pasture agronomy and management research, in terms of overall farm business priorities the overall level of importance placed on pasture improvement/ management/ regeneration ranks well below (7%) that of increasing efficiency (35%) and expansion and increasing the scale of production (33%).

[43] Hooper, S 2007, *Meat & Livestock Australia management practices survey 2005-06,* ABARE
[44] Levantis, C and Hooper, S 2009, *Meat & Livestock Australia management practices survey 2007-08,* ABARE

6.0 Recommendations

6.1 Soil Nutrient Balance for Productive Pastures**:**

It is recommended that MLA invest in R & D project areas which are related to improving the efficient, effective and economic management of the soil nutrient base with an emphasis on the following areas of research:

i) Optimising and sustaining productivity and plant water use efficiency;

ii) Adoption of strategies that are environmentally benign;

iii) Recognising and minimising adverse soil processes, such as soil acidification; and

iv) Avoiding nutrient imbalances through evaluation and management.

v) Agronomic and environmental screening of exotic and native pasture plant species for increased persistence and which may be suitable for adoption in southern Australia.

vi) Genomic screening of plant species and organisms for persistence related traits and mechanism, including endophytes which are benign to the target pasture species, livestock and the environment.

vii) Physiological and morphological screening of current pasture species for selection and commercialization of "elite" lines which demonstrate superior levels of persistence.

6.2 Pasture Agronomy and Management for Productive Pastures:

It is recommended that the focus of MLA's pasture agronomy and management R & D be directed to projects that will contribute to the re-establishment and improvements to the productive capacity of the feedbase with an emphasis on the following areas of research:

i) Agronomic and environmental screening of exotic and native pasture plant species for increased persistence and which may be suitable for adoption in southern Australia.

ii) Genomic screening of plant species and organisms for persistence related traits and mechanism,

iii) Screening of endophytes which enhance perennial grass persistence and are benign to the target pasture species, livestock and the environment.

iv) Physiological and morphological screening of current pasture species for selection and commercialization of "elite" lines which demonstrate superior levels of persistence.

v) Enhancement of root morphology for more efficient nutrient up-take;

vi) Enhancement of legume root morphology for effective production of nitrogen;

vii) Enhancement of plant species tolerance to:

a. root diseases and nematodes;

b. environmental stress such as drought and frost;

c. pests such as aphids and earth mites.

viii) Alternate perennial/annual grasses, legumes, fodder crops and shrubs for improved:

a. Pasture composition;

b. Filling the summer feed gap;

ix) The establishment of a cost/benefit analysis focused on assessing the potential incremental gains in pasture and livestock management and productivity following the adoption of pasture monitoring tools and management programs.

x) The development and adoption of tools that will allow producers to monitor the performance of pastures and assist in the establishment of regular forage/pasture budgets to meet livestock requirements,

xi) The development and adoption of tools and processes that assist producers/service providers to increase pasture performance.

xii) The development of technologies/tools and the implementation of management strategies that will improve the persistence of key species and/or will reduce the risk of pasture decline.

Appendix One: MLA R, D & E Reviews and Strategy Documents

Reference Documents	
Research & Development	• R. Coffey, 2010, Pasture Australia Outputs • D. Hudson et al, 2009, Pastures Australia Review • J. Black, L. Scott, 2002, More Beef From Pastures - Current knowledge, adoption and research opportunities. • A. Lazenby, T. Wolfe, P. Chudleigh, 2002, A Review of Pasture Evaluation & Improvement Investment for the Lamb. Sheep meat and Beef Industries. • Holmes Sacket, 2009, Southern Beef Situation Analysis. • Hassall & Associates, 2009, Economic Analysis of Sheep Production Systems
Extension & Adoption	• Hooper, S 2007, *Meat & Livestock Australia management practices survey 2005-06,* ABARE • Levantis, C and Hooper, S 2009, *Meat & Livestock Australia management practices survey 2007-08,* ABARE • GHD Hassall, Axiom Research, 2009, Report for External Review of MBfP and MMfS Programs. • John Logan, Axiom Research, 2009, Meat & Livestock Australia Awareness & Adoption KPI Evaluation. • GHD Hassall, 2009, Making More from Sheep Report on Extent of Practice Change. • Dr. Richard Price, 2009, A Report of the Grain & Graze National Operations 2003 – 2008. • G. Stewart, 2008, A National extension approach supporting regional paradigms – lessons from the Grain & Graze program.
Livestock Meat Industry R & D Strategic Plans	• Primary Industries Standing Committee – R&D Sub-Committee 2010 , National Sheep meat Production RD&E Strategy • Primary Industries Standing Committee – R&D Sub-Committee 2010 , National Beef Production RD&E Strategy • Red Meat Advisory Council, 2009, Meat industry Strategic Plan 2010 – 2015. • Meat & Livestock Australia, 2005, MLA Southern Beef Program Livestock Production Research & Development Strategic Plan 2006-2011 • Meat & Livestock Australia, 2005, MLA Livestock Production Research & Development Strategic Plan 2006-2011

Research & Development Priorities Related to Pasture Agronomy & Management					
MLA R & D Priority 2011	**MLA FIP Review 2010**	**MLA Strategic Plan 2010**	**Pastures Australia Review 2009**	**More Beef from Pastures Review 2002**	**MLA Pasture Evaluation & Improvement Investment Review 2002**
Pasture Health: Improved pasture nutrition through a combination of increased soil fertility, and/or fertiliser precision, and/or soil biological processes	Soil fertility. Soil biology.	Enhance rates of genetic improvement in flock, herd and feedbase performance.		Strategic use of fertilisers to maximise pasture growth	
Pasture Composition: Increased content of desirable species and increased consistency of legumes in pastures	Improvement of legumes. Improvement of introduced perennial grasses. New species		Re-establishing the role of Legumes in Permanent Pastures and Crop Rotations.	Selection of the most suitable plant species and cultivars for specific sites in pasture regeneration programs to ensure maximum yield, sustainability and growing season	Selecting perennial legumes for the Northern Tablelands and NW Slopes of NSW Conventional pasture plant breeding Botanical composition
Pasture Maintenance: Reduced incidence off and impact from, abiotic and biotic stresses in pastures.	Weed control Insect pest control				Selecting perennial and salt tolerant species for dry-land salinity Weed control
Pasture Management: Pasture management tactics that improve pasture persistence, productivity and quality and that address feed gaps and seasonal variability.	Pasture utilisation/grazing management. Improvement of introduced perennial grasses. Pasture establishment techniques. Improvement of fodder crops Improvement of annual / biennial grasses Improvement of native species	Increase feed productivity and sustainability. Develop and promote information and tools that help natural resource management and productivity.	Sustainable Pasture Management Systems for Mixed Farming Enterprises. Increased Adoption of Pasture Improvement Strategies.	Manage existing pastures to maximise growth and quality through strategic defoliation and minimisation of fouling, pugging and soil erosion Review options for the management of excess spring pasture.	Selecting perennial grasses for low input systems Sustainability studies
Productive Pastures: Tools and processes to assist meat producers and service providers increase pasture performance.	Decision support systems Pasture establishment techniques.	Optimise utilisation rates and productivity in grazing and feeding systems. New or improved tools to support the More Beef from Pastures decision support framework.	Improved Value of Pastures.		Biotechnology A National Decision Support System Development of management packages Extending the use of GrassGro

Appendix D

Grazing Management and Production Systems

Background Narrative

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Executive Summary

This review has been prepared to provide the background and industry context for future research and development with grazing management and production systems. Investment is planned by Meat and Livestock Australia (MLA) for the Southern Australian feedbase to address the needs of leading producers through research which stretches beyond known science and integrates both feedbase and livestock needs.

The main distinguishing features of the most profitable livestock businesses are higher stocking rates, better pasture production and grazing management and superior genetics. Grazing management is an important component of resilient agricultural systems that can support high stocking rates while minimising climatic fragility and risk exposure. Given the importance of stocking rate and grazing management to enterprise profitability and environmental sustainability it is critical that attention of the research, advisory and producer community remains focused in this area.

The Feedbase Investment Plan (Shovelton et al. 2011) commissioned by Meat & Livestock Australia on behalf of the Red Meat Co-investment Committee identified (i) pasture utilisation and risk management; (ii) perenniality and environmental outcomes; (iii) livestock performance; and (iv) the role of crops and shrubs for grazing as the key researchable deliverables within the *Grazing Management and Production Systems* program area. In this report the focus of R&D since 2000 in these areas is reviewed and future opportunities identified.

Considerable knowledge about grazing management and production systems has been developed since the 1990s and much of this research has been conducted through key industry programs which have typically encouraged cross-organisational interactions among scientists. This progress has revealed the next or remaining barriers to productivity gains which are summarised. The role of future research and development in grazing management and production systems is to optimise stocking rates through better managing pasture utilisation in concert with enterprise flexibility. These changes must improve labour efficiency, optimise legume content, produce agricultural systems that are resilient to climatic fragility, manage risk and meet market specifications. These requirements indicate that innovations must provide multiple benefits for leading producers.

Pasture utilisation and risk management: Increasing pasture utilisation is often managed by increasing stocking rates and while this is an important way to increase profit it may also expose livestock enterprises to greater risk. The collection of information on pasture and livestock performance remains laborious and poorly integrated with farm business goals and providing remote and real-time collection should be the focus of future research and development.

Perenniality and environmental outcomes: The management requirements to ensure perenniality of tropical pasture swards and the management requirements to encourage legume persistence in temperate and subtropical pastures remain uncertain. Specifically, the complex relationships between deep-rooted lucerne and perennial grasses need to be better understood including the role of grazing management in controlling competition for moisture and ensuring sufficient ground cover

Livestock performance: While beneficial effects of grazing management on pastures have been demonstrated over a wide range of agro-ecological regions, the advantages for livestock production

are equivocal and often fail to meet expectation. A number of reasons were discussed to account for this anomaly but the importance of mob size and stock density remained unresolved. Also lacking is real-time remote data collection of animal performance, health and welfare to inform grazing and other management activities in consideration of target market specifications.

Role of crops and shrubs for grazing: What remains unclear is the relative advantage and complexity of multiple enterprises and how the out of season feed provided by shrubs, cereals and oilseeds affects year-long activities and enterprise profitability. Integration of these practices has the potential to add considerable value to livestock enterprises but increased complexity is associated and warrants investigation.

Tools to help assess management options: Opportunity has been identified arising from the remote digital real-time collection of pasture and livestock performance to inform grazing and other management activities. That information needs to be interpreted - in light of livestock, pasture and natural resource targets - and optimal actions suggested to guide grazing and production systems in consideration of enterprise, market specification, enterprise profit, risk exposure and complexity.

A program of research projects that addresses some or all of these barriers is likely to deliver large productivity gains to grazing businesses. Industry estimates are of productivity gains for leading producers in the order of 20% with simultaneous improvements for natural resource management. These estimates may be exceeded when advances with grazing management and production systems are integrated with improvements in plant species and their agronomy.

Grazing Management and Production Systems

Introduction

This review has been prepared to provide the background and industry context for future research and development with grazing management and production systems. Investment is planned by Meat and Livestock Australia (MLA) for the Southern Australian feedbase to address the needs of leading producers, those 15-20% of producers who have already adopted existing technologies and are looking for new innovations to improve their livestock businesses. The planned investment is for the conduct of research and development but not for extension, which will be the basis of a later call by MLA. The nomination of leading producers as the target market for research and development brings into focus the need for research to stretch beyond the known science and to ultimately integrate both feedbase and livestock needs.

Livestock Industries and Grazing Management

Livestock industry and future trends

The size of the beef cattle herd across the agro-ecological regions of southern Australia declined from 10.2 million head in 2001 to 9.7 million in 2009. The reduction in the sheep flock was relatively greater with the total number of sheep and lambs falling from 101.5 million in 2001 to 68.5 million in 2009 (Shovelton et al, 2011). It is possible that the downward trend will soon turn around with the Australian Bureau of Agricultural and Resource Economics (ABARE) predicting growth in the number of beef cattle and sheep within southern Australia by 2015.

ABARE's projections are for an increase in beef cattle numbers and it can be calculated (Shovelton et al, 2011) that between 2010 and 2105 the cattle herd within southern Australia has the potential to increase cumulatively by approximately 720,000 head. ABARE also predict a moderate increase in the size of the national sheep flock with an increase of 5.1 million head between 2010 and 2015. The projected increases in stock numbers on a per hectare basis are small (0.2-0.6 DSE/ha) in relation to the existing potential to increase stocking rates and should be comfortably met through the adoption of existing technologies.

The Temperate Slopes and Plains region generates the majority of the value derived from cattle and calf meat sold contributing $1.07B (32.6% of total) in 2009. In the same manner, the value generated from the sale of sheep and lamb meat was dominated by the Temperate Slopes and Plains region which contributed $1.41B (58.7%) in 2009.

Priorities for future research

An industry survey including consultation with key people representative of sectors and agro-ecological regions within the Feedbase industry of southern Australia was recently completed to identify future research priorities (Shovelton et al, 2011). The consultation process collected 576 responses from within the Feedbase industry with thorough sampling across industry sectors and agro-ecological regions. The consultation used industry knowledge and many of the participants had

experience from other RD&E programs. Of all the factors known to affect the productivity and sustainability of red meat production, respondents nominated pasture utilisation and grazing management of highest priority for on-going research. The relative ranking of these factors increased in more arid agro-ecological regions, presumably because of fewer viable options in terms of soil fertility and pasture establishment.

Adopted grazing management practices

Adoption of managerial innovations by the livestock industry is generally slower than adoption of product innovations. Product innovations (e.g. pasture species, fertiliser type, sire bloodline) can be (though not necessarily successfully) adopted with few changes in whole-farm management and are therefore simpler and more easily trialable. In contrast, managerial innovations (e.g. grazing management, enterprise choices) are more far-reaching and complex and challenge the way producers do business. This does not mean that managerial innovations are less effective but rather that extension and adoption pathways need to be more carefully considered and integrated into whole-farm businesses. For example, in a review of industry practices used to improve pasture utilisation and natural resource management, Barnett (2007) reported that few industry extension programs have resulted in broad adoption of practices and technologies among their specific target markets. The reasons provided by Barnett (2007) included the perception among producers of increased complexity and risk arising from higher stocking rates, exposure to market and climatic risk and restriction of relative advantage to the 'high input – precision' farming sector.

Despite these challenges for adoption, Holmes Sackett (2009) state that the main ways to increase productivity in a herd are to optimise stocking rate, ensure optimum age and weight at sale and optimise herd weaning weight. The additional benefit of optimum stocking rate (and hence pasture utilisation) is to increase labour efficiency and decrease cost of production where wages can account for 25% of costs to beef and sheep enterprises. These authors suggest that the labour efficiency of producers in the top 20% is 15,500 dse per full-time equivalent for beef cattle and 10,500 dse for sheep enterprises. In a comparison of the profitability of the top and bottom 20% of livestock properties (Hassell and Associates, 2004), the main distinguishing features of the most profitable were higher stocking rates, better pasture production and grazing management and superior genetics.

Given the importance of stocking rate and grazing management to enterprise profitability it is critical that attention remains focused in this area. The next section will review the focus of R&D since 2000 to record the principal achievements and the extent to which outcomes have been adopted by industry.

Recent Research and Development

Grazing systems research since the mid 1990s has dealt principally with ways to increase the productivity of livestock enterprises, the sustainability of natural resources and the integration of livestock and crops. This has largely informed the objectives of major research projects such as Temperate Pastures Sustainability Key Program (Mason and Kay, 2000), Sustainable Grazing Systems (Mason et al, 2003), EverGraze (Avery, 2004; Masters, 2006), Grain & Graze (Price, 2008) and Enrich (Revell et al., 2009). Key objectives have differed among agro-ecological regions of southern Australia but focus has remained with increasing pasture growth and utilisation, encouraging

perenniality and exploring the out of season growth advantages offered by the grazing of crops and shrubs.

The Feedbase Investment Plan (Shovelton et al. 2011) commissioned by Meat & Livestock Australia on behalf of the Red Meat Co-investment Committee identified the key researchable deliverables within the *Grazing Management and Production Systems* program area that are required to further advance industry gains. These deliverables contain the key components of:

- Pasture utilisation and risk management
- Perenniality and environmental outcomes
- Livestock performance
- Role of crops and shrubs for grazing
- Labour efficiency
- Strategic use of containment feeding
- Tools to help assess management options

The progress that industry has made with these key deliverables in the last 10-15 years is reviewed and future opportunities identified. Innovations for increasing pasture growth rate (i.e. soil fertility or improved species) will be discussed in other narratives and so focus in this report is provided on the harvest (i.e. grazing) process and it's integration with forage provided by crops and shrubs.

Grazing management

Grazing practices of livestock producers were documented in southern Australia for the year 2003 (Reeves and Thompson, 2005). At that time, some 48% of producers practised set stocking and 38% practised some form of rotational grazing. The term grazing management has been defined by a number of authors but a general definition is the control of the number and movement of animals across a farm in balance with pasture availability and species growth and tolerance of grazing. These factors must also recognise the different requirements inherent in meeting market specifications for livestock. Grazing management balances the need for production, sustaining pastures and managing natural resources and while either may be favoured at a particular time, or on a particular part of a farm, or with a particular group of animals, it is the balance between these factors over the long period that is most important.

The extent of pasture utilisation is often considered as an important part of grazing management but it is important to note that utilisation can be independent of grazing pattern and is mostly associated with the matching of stocking rates to land capability. Grazing management may help to manage pasture utilisation through greater paddock subdivision leading to better control over the locational preferences of grazing livestock. Grazing management and soil fertility are the critical management factors that regulate pasture growth rate, composition and exposure to resource degradation and subsequent livestock production.

It has become increasingly apparent that the effect of grazing rotation on pastures is mediated principally through utilisation, frequency, severity and, in annual-dominant environments or with some pasture species, the timing of grazing. While positive effects for pastures and natural resources are now well documented, the role of grazing management to improve livestock production is less clear.

Pasture utilisation and risk management

Pasture utilisation is defined as the proportion of pasture growth that is consumed by animals. Utilisation can be regulated by manipulating pasture growth or stocking rate or both these factors in combination. Black and Scott (2002) indicated that only 30-40% of pasture is utilised annually in the southern Australian beef industry and that a target should be set to increase utilisation by a further 5% points. Low rates of utilisation are often a risk management tool used by producers to control for variation in seasonal pasture production thereby providing protection against periodic drought, a reduced requirement for purchased feeds and reduced threat to natural resources, in particular the maintenance of ground cover. But there are other barriers to increased pasture utilisation, achieved through greater stocking rates, such as a preference for measuring stockmanship through production per head (easily visible) rather than production per hectare (requires calculation), concern for meeting market specifications and inadequate flexibility in livestock enterprises to respond to adverse or favourable seasonal events.

Annual rates of pasture utilisation are a useful benchmark but hide variation that may exist among seasonal rates of utilisation. For example, utilisation will typically exceed 100% during the non growing season when daily pasture growth rate falls below the demands of a particular stocking rate. Conversely, utilisation may fall to a very low level during peak pasture growth and it is this factor that typically accounts for low annual utilisation values. Low seasonal pasture utilisation leads to an accumulation of herbage and a reduction in feed quality associated with increased content of senescing and dead plant material and lower legume content. Paradoxically this trade-off between pasture quality and quantity encourages even lower rates of utilisation because pasture intake by livestock declines with lower digestibility and crude protein. Even the notion of a fixed rate of utilisation appears questionable because a target rate of utilisation (say 60%) does not account for differences in yearly pasture production. If yearly pasture production amounted to 5,000 kg DM/ha the residual mass of pasture would be 2,000 kg (i.e. 5000 – {5,000 x 0.60}). If however yearly pasture production increased to 8,000 kg DM/ha and utilisation remained at 60%, residual pasture would be increased to 3,200 kg DM/ha.

Increases in pasture utilisation need to be carefully managed because high rates of utilisation, particularly during the growing season can reduce pasture growth rate and shift botanical composition in an undesirable direction away from perenniality (Humphreys, 1991). As such, pasture utilisation is part of a circular loop with positive feed forward and negative feedback for pasture growth and composition and livestock performance. Management of paddock size and stock density can also be used to help control uneven utilisation of pastures within a paddock but the management of heterogeneous grazing habits of livestock is not well understood.

Increased stocking rates also need to be carefully managed because of the tension between individual animal production, production per hectare, risk exposure and negative feedback on pasture growth. In any of the southern agro-ecological regions, production per hectare will be optimised at a stocking rate higher than for production per head (Robinson, 1982): this shift leads directly to increased labour efficiency. However, seasonal variability can result in higher stocking rates exposing producers to increased risk leading to periodic excessive utilisation and loss of perennial pastures. It is under this circumstance that enterprise flexibility (i.e. proportion of

breeding and trading stock units) and forward planning skills are required to manage the risk and ensure livestock meet market specifications.

The implementation of optimised livestock systems utilising data collected locally and remotely from livestock, pasture and other natural resources will be part of the suite of tools required to enable livestock producers to manage pasture utilisation while meeting livestock market specifications. There has been development in this area including the remote sensing of pasture mass and growth rate through the *Pastures from Space* project, automated detection of live weight and pedigree using walk-over-weighing, remote logging of animal movement using GPS tracking and the exploration of virtual fencing systems. These tools are at various stages of development but it is clear that simply providing information, without the context of management action, is not likely to lead to effective market penetration of these technologies.

Increasing pasture utilisation is often managed by increasing stocking rates but the positive feed forward and negative feedback loops are still not fully understood and insufficiently quantified in terms of pasture and animal production, botanical composition and transfer of plant carbon to soil pools. The collection of information on pasture and livestock performance remains laborious and poorly integrated with farm business goals. The enterprise flexibility to manage risk and climate variability requires development because of the importance of optimising production and creating resilient agricultural systems.

Perenniality and environmental outcomes

Modeling of grazing systems for southern high rainfall zones has highlighted the importance of perennial pastures for providing out of season pasture, stable ground cover, increased water use and reduced deep drainage to ground water. Unfortunately the persistence of most perennial pasture species is fragile and grazing management is a critical factor regulating persistence.

Prior to the mid 1990s, debate existed as to the relative merits of grazing management practices on pasture productivity and composition and the direct and flow-on effects of such practices on animal production (Hart *et al*. 1988; Kirkman and Moore 1995; Heitschmidt and Walker 1996; Norton 1998). Research since that time has highlighted the disadvantages of continuous grazing and the advantages of rotational grazing for the perenniality of pastures. Several cues have been used to guide decisions about the timing of introduction, the number of livestock and their removal from a paddock. For example, the management of residual herbage mass before and after a grazing event (Dowling *et al*. 1996; McKenzie and Tainton 1996; Kahn *et al*. 2010); the length of time of grazing events (Taylor *et al*. 1993; Earl and Jones 1996); the length of time between grazing events (Taylor *et al*. 1993; Earl and Jones 1996; Bowman *et al*. 2009); the number of leaves per tiller (Fulkerson and Donaghy 2001); and the phenology of designated desirable and/or undesirable plant species (Whalley *et al*. 1978; Lodge and Whalley 1985; Garden *et al*. 2000).

The combined effect of this research has been to identify key targets for grazing management that aid perenniality. For example in high rainfall zones ensuring that (i) grazing occurs only when herbage mass exceeds a value of 2,000 – 3,000 kg DM/ha (species and phenology dependent) or when the number of leaves per tiller is 3-4 (species dependent); (ii) grazing does not reduce herbage mass below 1,000 – 2,000 kg DM/ha (species and seasonal dependent); (iii) grazing occurs within a

time frame that minimises the chance of multiple defoliation events; (iv) grazing is managed with cognoscente of preferred phenology. Lower rainfall zones can also benefit from adopting targets to guide grazing decisions but focus is also placed on ground cover maintenance and the availability of fodder shrubs and medic burr.

The benefit of grazing management for producing agricultural systems resilient to change was demonstrated by Kahn (2008) in the Northern Tablelands of NSW. Higher stocking rates (9 vs 5 ewes/ha) achieved by increasing the rate of pasture utilisation with continuous grazing were fragile to climatic influence and associated with large year to year variability in livestock and pasture performance. In contrast, grazing management that utilised some of the cues described above were reliable and allowed equally high stocking rates while minimising climatic fragility and risk exposure and increased gross margin return by $103/ha. This approach led to an increase in litter a reduction in the density and area covered by thistles (*Cersium vulgare* and *Carduus tenuiflorus*) and a greater rate of rainfall infiltration (indicating greater soil porosity).

The role of grazing management to improve temperate perenniality and environmental outcomes is now well established which weakens the case for further research investment on the response of a particular species. This is not to suggest that knowledge in this area is complete – for example grazing management to control invasive perennial grasses has not always met with success – but rather that on the scale of investment priorities the marginal gain is uncertain. What is less certain are the management requirements to ensure perenniality of tropical pasture swards and the management requirements to encourage legume persistence in temperate and subtropical pastures. Specifically, the complex relationships between deep-rooted lucerne and perennial grasses need to be better understood including the role of grazing management in controlling competition for moisture and ensuring sufficient ground cover.

Livestock performance

While beneficial effects of grazing management (rotational based on one or a number of the cues discussed earlier) on pastures have been demonstrated over a wide range of agro-ecological regions, the advantages for livestock production are equivocal (Holechek et al, 1999). Increases in yearly pasture production, ground cover and perenniality have not typically been converted into greater livestock production. At the same time greater variation in the performance of individual animals within mobs has often been reported. There are a number of reasons that may account for these anomalies. Firstly, unless increases in pasture production are matched by stocking rate, pasture utilisation and feed quality are likely to decline: this is the victim of the pastoral success syndrome. Secondly, commercial businesses that have adopted grazing management have often redirected variable expenditure from fertiliser to capital expenditure on fences and water points and have not then recontinued the fertiliser program after capital expenditure has been completed: the consequence being reduced pasture quality and performance. Thirdly, there has been an unhelpful preoccupation by some advisors and producers that grazing management is a time-based pasture-focused procedure moving animals in a routine order around paddocks without deliberate matching of pasture supply and quality with livestock demand.

There are exceptions where grazing management has been associated with an increase in stocking rate (Kahn et al, 2010; Badgery, pers. comm) and an increase in gross margin return (Kahn, 2008) but

these examples relied on the use of herbage mass thresholds to guide pasture and livestock management. The use of bigger mobs and higher stock density (animals/ha in a given paddock) may also lead to the fouling and/or trampling of pasture which, if not managed, will decrease livestock performance. There are also clear benefits derived from grazing management in reducing infection of sheep from the blood-sucking parasite, Barber's Pole worm (*Haemonchus contortus*) (Colvin et al, 2008). Nevertheless it is fair to say that livestock production has generally not matched expectation given the favourable changes in pasture production and this presents as a significant barrier to industry adoption. It may be that selection of livestock for resilience characteristics will improve their ability to perform under these management environments.

The consequence of larger mobs on livestock production is uncertain, poorly researched and often confounded with stock density. For example, a stock density of 500 DSE per ha could arise from a mob of 500 cattle (say 10 DSE/head) grazing a 10 ha paddock or from a mob of 50 cattle grazing a 1 ha paddock. While this empirical knowledge is lacking so is real-time remote data collection of animal performance, health and welfare to inform grazing and other management activities in consideration of target market specifications.

Role of crops, shrubs and niche pasture species for grazing

The role of grazing cereals and to a lesser extent, oilseeds, has increased to become a common practice in some of the agro-ecological regions of southern Australia. There are also important examples of fodder shrubs/trees such as tagasaste (for temperate areas of deep acid sands), leucaena (for tropical areas with deep well-drained fertile soils) and old man saltbush (for low rainfall areas and saline lands). There are benefits that accrue to cropping enterprises particularly from the role that legume break crops play with disease control and provision of nitrogen to the following crop. Interest in forage shrubs in lower annual rainfall (350 mm) regions has also increased recently and this has principally been through the activities of the Enrich project (Revell et al, 2009). The common element to the grazing of crops and shrubs is the role of filling feed gaps by providing out of season production (Moore et al, 2009) and reducing the need for purchased feeds. High quality forage grown during winter also allows a change in the timing of key livestock activities and provides a means for overwintering more animals to better utilise peak spring pasture production and to ensure herbage mass targets for spring are more readily met. It is this role and the impact on enterprise choice that remains of interest for leading producers.

The nutritional value of forage shrubs can be complex as plant crude protein is sometimes only poorly digestible for livestock and mineral content (especially sodium) can be imbalanced and high and intake dependent on water quality (Norman et al, 2008). Similarly, winter wheat used for grazing is typically deficient in sodium and marginal for magnesium and significant growth responses have been observed in lambs after these minerals were provided (Dove and McMullen, 2009). Fodder shrubs and trees can provide out of season feed in otherwise annual or seasonally-dominant systems and provide a more stable basis for livestock systems.

Provision of fodder shrubs and trees increases the complexity of forage systems and may rely on learned responses by grazing livestock to effectively utilise the browse. Grazing management remains incomplete in relation to integration of these feed sources within the whole farm, as they typically occupy only a small proportion of the farm often characterised as more marginal areas.

Where grazing management information has been collected with grazing cereals, no advantage from rotational grazing of winter wheat over a 7-week period was observed (Miller et al. 2010) during which time lambs gained the equivalent of 336 kg/ha.

What remains unclear is the relative advantage and complexity of multiple enterprises and how the out of season feed provided by shrubs, cereals and oilseeds affects year-long activities and enterprise selection and profitability. The competition between livestock and cropping is likely to intensify and spread into higher rainfall regions but additional grazing, without expense to yields, is likely to mitigate this competition. Integration of these practices has the potential to add considerable value to livestock enterprises but increased complexity is associated and warrants investigation.

Tools to help design and manage livestock systems

In this review, opportunity has been identified arising from the remote digital real-time collection of pasture and livestock performance to inform grazing and other management activities that optimise stocking rate, livestock and pasture performance and livestock health and welfare. That information needs to be interpreted - in light of livestock, pasture and natural resource targets - and optimal actions suggested to guide grazing and production systems in consideration of enterprise, market specification, enterprise profit, risk exposure and complexity. Those actions may also relate to pasture utilisation, the role of crops and shrubs and the requirements of containment feeding. Yet these tools (or models) must be accessible to leading producers and their advisors to ensure industry adoption.

Key Current Investments

The key large-scale investments that are active in the area of grazing management and production systems in southern Australia are provided below. Investment is provided by Meat & Livestock Australia, Future Farm Industry CRC, Australian Wool Innovation and Grains Research and Development Corporation. There is the scope for close association for the CRC for Sheep Industry Innovation.

EverGraze - The aims of the EverGraze project were to design, research and validate new livestock production systems, utilising sown and native perennial pastures, in high rainfall zones that achieve the dual outcomes of (i) an increase in profitability by 50% (above current best practice); and (ii) a significant improvement of catchment relevant natural resource management outcomes – principally related to a reduction in recharge by 50% over annual systems, maintenance of ground cover and persistence of perennial pastures. The target for the adoption of the principles and practices to emerge from project activity is 3,600 properties across the high rainfall zone through an active partnership between agencies, Catchment Management Authorities, agribusiness and R&D Corporations.

Enrich - The Enrich project has taken a multi-pronged approach to assessing the potential role of forage shrubs by (i) quantifying the potential of shrub species for providing specific nutrients or beneficial bioactive compunds to improve animal productivity and health; (ii) exploring Australian native shrubs species more thoroughly than we've done before given their inherent capacity to survive and grow in our climate; and (iii) exploiting the capacity of grazing herbivores to 'mix and match' different components from a diverse offering of plant species, and designing management principles that provide animals with experiences of otherwise novel plants to ensure a diverse range of plants are selected in their diet.

Grain and Graze - The Grain & Graze program aimed to boost farm profitability across the mixed farming zone of southern Australia, while helping to protect the environment. Research focused on cropping, pastures, livestock, profitability, feedbase management, whole-farm economics, biodiversity, social issues, soil and water. A strength of the program was the direct involvement of farmers and farming groups in local trials and extension activities.

Opportunities for Research Investment

The role of research and development in grazing management and production systems is to optimise stocking rates through better managing pasture utilisation in concert with enterprise flexibility. These changes must improve labour efficiency, optimise legume content, produce agricultural systems that are resilient to climatic fragility, manage risk and meet market specifications. These requirements indicate that innovations must provide multiple benefits for leading producers.

Pasture utilisation and risk management: Increasing pasture utilisation is often managed by increasing stocking rates and while this is an important way to increase profit it may also expose livestock enterprises to greater risk. Pasture utilisation is difficult to quantify and the positive feed forward and negative feedback loops are still not fully understood and insufficiently quantified in terms of pasture and animal production, perenniality and the required enterprise flexibility (i.e. proportion of breeding and trading stock units) to manage seasonal variability. The collection of information on pasture and livestock performance remains laborious and poorly integrated with farm business goals and these factors should be the focus of future research and development.

Perenniality and environmental outcomes: The role of grazing management to improve temperate perenniality and environmental outcomes is now sufficiently established as to weaken the case for further research investment. What is less certain are the management requirements to ensure perenniality of tropical pasture swards and the management requirements to encourage legume persistence in temperate and subtropical pastures. Specifically, the complex relationships between deep-rooted lucerne and perennial grasses need to be better understood including the role of grazing management in controlling competition for moisture and ensuring sufficient ground cover

Livestock performance: While beneficial effects of grazing management on pastures have been demonstrated over a wide range of agro-ecological regions, the advantages for livestock production are equivocal and often fail to meet expectation. A number of reasons were discussed to account for this anomaly but the importance of mob size and stock density remained unresolved. Also lacking is real-time remote data collection of animal performance, health and welfare to inform grazing and other management activities in consideration of target market specifications.

Role of crops and shrubs for grazing: What remains unclear is the relative advantage and complexity of multiple enterprises and how the out of season feed provided by shrubs, cereals and oilseeds affects year-long activities and enterprise profitability. Integration of these practices has the potential to add considerable value to livestock enterprises but increased complexity is associated and warrants investigation.

Tools to help assess management options: Opportunity has been identified arising from the remote digital real-time collection of pasture and livestock performance to inform grazing and other management activities. That information needs to be interpreted - in light of livestock, pasture and natural resource targets - and optimal actions suggested to guide grazing and production systems in consideration of enterprise, market specification, enterprise profit, risk exposure and complexity.

Conclusions and Recommendations

Livestock numbers are predicted to increase in the next 5 years and existing technologies will be sufficient to meet the expected increase in stocking rate. However, stocking rate remains one of the key factors that distinguishes profitable livestock businesses and grazing management is required to deliver benefits for the triple bottom line of profit, environment and social (in the form of risk management). Since the mid 1990s, there has been a large advance in understanding of the role that grazing management plays in pasture and livestock performance but opportunities remain. For example, pasture utilisation and risk management, regulation of perennial competition by grazing, capturing the benefits of grazing management in livestock performance, integrating shrubs and/or crops into grazing businesses to allow out of season production and better management of peak pasture growth and in the provision of decision support tools to integrate information and provide optimal actions. Grazing management plays a larger role on farms because of it's ability to enhance the persistence of sown perennial pastures – and therefore amortise establishment costs over a longer period – and lower maintenance fertiliser requirements. The next 5-10 years provides the opportunity to better understand these factors and have highly productive, profitable and resilient grazing businesses as the basis for satisfying any consumer demands about the merits of red meat production.

The identification of leading producers as the target market for research and development brings into focus the need for research to stretch beyond the known science and to ultimately integrate both feedbase and livestock needs. A priority for future research and development is the remote collection, interpretation and optimization of livestock and pasture data in real time because it is the laborious nature of data collection that acts as a barrier to change. There is still a need for collection of empirical data concerning pasture utilisation, livestock performance, pasture persistence, legume content and integration of out of season feed but this needs to be accompanied by innovation in remote data collection and optimization procedures relevant for the farm businesses.

References and Literature Reviewed

Avery A (2004) *Profitable Animal Production from Perennial Pastures Phase III-Implementation*. Proposal to CRC for Plant-Based Management of Dryland Salinity.

Barnett R (2007) *Best Practice Pasture Utilisation & Natural Resource Management, A Review of Current Extension Adoption*. Project number B.COM.0112.2, Meat & Livestock Australia.

Black J and Scott L (2002) *More Beef From Pastures*. Project Number SBP.004, Meat & Livestock Australia.

Bowman AM., Alemseged Y, Melville GJ, Smith WJ and Syrch CF (2009) Increasing the perennial grass component of native pastures through grazing management in the 400–600 mm rainfall zone of central western NSW. *The Rangeland Journal*, 31, 369–376.

Colvin AF, Walkden-Brown SW, Knox MR and Scott JM (2008) Intensive rotational grazing assists control of gastrointestinal nematodosis of sheep in a cool temperate environment with summer-dominant rainfall. *Veterinary Parasitology*, 153, 108-120.

Dove H and McMullen KG (2009) Diet selection, herbage intake and liveweight gain in young sheep grazing dual-purpose wheats and sheep responses to mineral supplements. *Animal Production Science*, 49, 749-758.

Dowling PM, Kemp DR, Michalk DL, Klein TA and Millar GD (1996) Perennial grass response to seasonal rests in naturalised pastures of central New South Wales. *The Rangeland Journal*, 18, 309–26.

Earl, J. M., and Jones, C.,E. (1996). The need for a new approach to grazing management – is cell grazing the answer? *The Rangeland Journal*, 18, 327–350.

Fulkerson WJ and Donaghy DJ (2001) Plant-soluble carbohydrate reserves and senescence - key criteria for developing an effective grazing management system for ryegrass-based pastures: a review. *Australian Journal of Experimental Agriculture*, 41, 261–275.

Garden DL, Lodge GM, Friend DA, Dowling PM and Orchard BA (2000) Effects of grazing management on botanical composition of native grass-based pastures in temperate south-east Australia. *Australian Journal of Experimental Agriculture*, 40, 225–245.

Hart RH, Samuel MJ, Test PS and Smith MA (1988) Cattle, vegetation, and economic responses to grazing systems and grazing pressure. *Journal of Range Management*, 41, 282–286.

Hassall & Associates (2004) *Economic Analysis of Sheep Production Systems*. Project Number SCSB.051, Meat & Livestock Australia.

Heitschmidt RK and Walker JW (1996) Grazing management: Technology for sustaining rangeland ecosystems? *The Rangeland Journal*, 18, 194–215.

Holechek JL, Gomes H, Molinar F, Galt D and Valdez R (1999) Short-Duration Grazing: The Facts in 1999. *Rangelands*, 22, 18-22.

Holmes Sackett (2009) *Southern Beef Situation Analysis*. Report for Meat & Livestock Australia.

Humphreys LR (1991) *Tropical Pasture Utilisation*. Cambridge University Press, Melbourne Australia.

Kahn LP, (2008) *Best Practice Management to Increase the Profitability of Merino Sheep Meat Production*. Project MS.028, Meat & Livestock Australia.

Kahn LP, Earl JM, Nicholls M (2010) Herbage mass thresholds rather than plant phenology are a more useful cue for grazing management decisions in the mid-north region of South Australia. *The Rangeland Journal*, 32, 379-388.

Kirkman KP and Moore A (1995) Perspective: Towards improved grazing management recommendations for sourveld. *African Journal of Range and Forage Science*, 12, 135–144.

Lodge GM and Whalley RDB (1985) The manipulation of species composition of natural pastures by grazing management on the northern slopes of New South Wales. *Australian Rangeland Journal*, 7, 6–16.

Mason WK and Kay G (2000) Temperate Pasture Sustainability Key Program: an overview. *Australian Journal of Experimental Agriculture*, 40, 121-124.

Mason WK, Lamb K and Russell B (2003) The Sustainable Grazing Systems Program: new solutions for livestock producers. *Australian Journal of Experimental Agriculture*, 43, 663-672.

Masters D (2006) *EverGraze Phase IV-More Livestock from Native Perennials*. Draft submission to CRC for Plant-Based Management of Dryland Salinity.

McEachern S, Sackett D and Holmes P (2005) *Keys to Profitable Lamb Production – 2005 and Beyond*. Project number SCSB.075, Meat & Livestock Australia.

McKenzie FR and Tainton NM (1996) Effect of grazing frequency and intensity on Lolium perenne L. pastures under subtropical conditions: herbage production. *African Journal of Range and Forage Science*, 13, 1–5.

Miller DR, Dean GJ and Ball PD (2010) Influence of end-grazing forage residual and grazing management on lamb growth performance and crop yield from irrigated dual-purpose winter wheat. *Animal Production Science*, 50, 508-512.

Moore A, Bell LW and Revell DK (2009) Feed gaps in mixed-farming systems: insights from the Grain & Graze program. *Animal Production Science*, 49, 736-748.

Moore AD, Robertson MJ, Bell LW, Doole GJ, Dove H, Hargreaves JNG, Herrmann NI, Holzworth DP, Lawes RA, Lilley JM, McIvor JM, Peake AS, Revell DK, Whish JPM and Whitbread AM (2008) *Grain & Graze National Feedbase Project Final Report*. Land Water Australia.

Norman HC, Mayberry DE, McKenna DJ, Pearce KL and Revell DK (2008) *Old man saltbush in agriculture: feeding value for livestock production systems*. Proceedings of the 2nd International Salinity Forum, Adelaide, Australia.

Norton BE (1998) *The application of grazing management to increase sustainable livestock production*. Animal Production in Australia, Proceedings of the Australian Society of Animal Production 22, 15–26.

PISC (2010) *National Beef Production RD&E Strategy*, Primary Industries Standing Committee.

PISC (2010) *National Sheepmeat Production RD&E Strategy*, Primary Industries Standing Committee.

Price, (2008) *Grain & Graze Project Management Report*

Reeve I and Thompson LJ (2005) Integrated Parasite Management in Sheep Project Benchmark Survey. http://www.wool.com/Grow_Animal-Health_Integrated-Parasite-Management_Integrated-Parasite-Management-sheep_IPM-s-National-Survey.htm, accessed 13-01-2011, Report for Australian Wool Innovation

Revell DK, Vercoe PE, Bennel l, Hughes M, Durmic SZ, Kotze AC, Monjardino M, Toovey AF, Phillips NP and Emms, J (2009) *The Enrich project: an overview of research aiming to develop multi-functional grazing systems with forage shrubs*. pp 119-130. Proceedings of the 50th Annual Conference of the Grassland Society of Southern Australia, Geelong, Victoria

Robinson G (1981) Stocking Rates – a tool of grazing management. *Landscene* No. 6, NSW Department of Agriculture.

Shovelton J, Kahn L, Thomas G, Pratley J and de Fegely C (2011) *Feedbase Investment Plan for Southern Australia*. Report commissioned by Meat & Livestock Australia.

Taylor CA, Brooks TD and Garza NE (1993) Effects of short duration and high-intensity, low-frequency grazing systems on forage production and composition. *Journal of Range Management*, 46, 118–121.

Whalley RDB, Robinson GG and Taylor JA (1978) General effects of management and grazing by domestic livestock on the rangelands of the Northern Tablelands of New South Wales. *Australian Rangeland Journal*, 1, 174–190.

Appendix E

[Development of the Call for Projects]

Action Plan following MLA receipt of the FIP (Feedbase Investment Plan[1])
The FIP included an overview of the R&D needs and potential program/project areas (see Table 1), meaning the next step was to flesh out the actual investments and the project level detail.

Table 1 – Summary of the research programs, major themes and research objectives from the FIP.

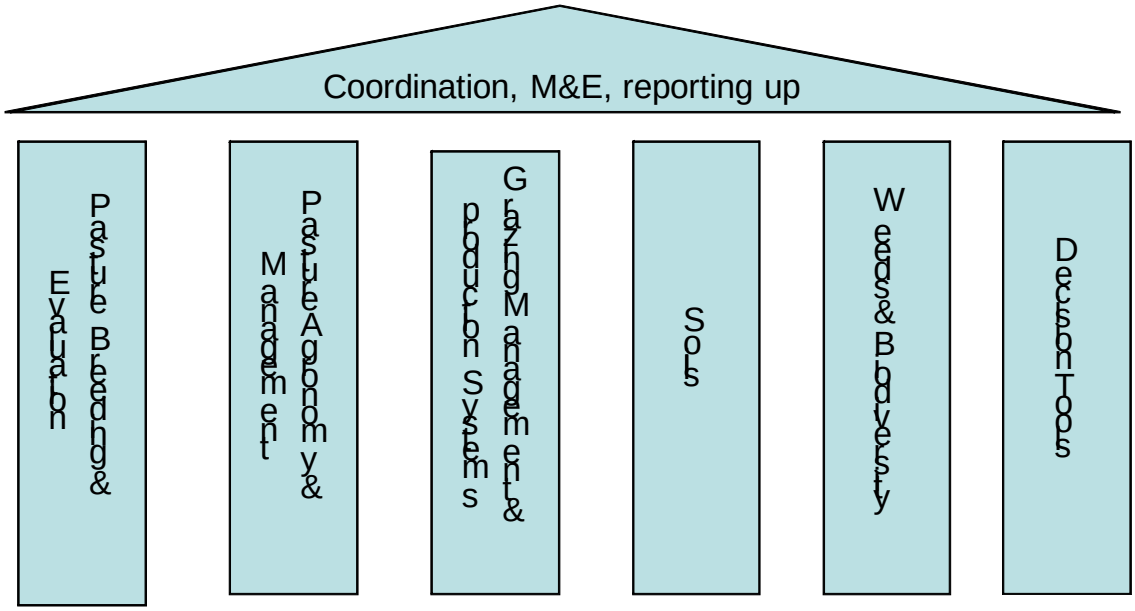
Research Program	Major themes	Research objectives
Plant Improvement	Evaluation and selection programs	• Implement an independent plant evaluation and selection program using appropriate quantitative genetic and genomic technologies to improve the persistence, quality and productivity of existing keystone species and evaluation of new species.
		• Selection to provide the base pasture traits identified through the consultation process. These traits are required for all the pasture species which are listed below. Species specific traits, in addition to the deliverables for this objective, are provided below.
	Legumes	• Selection to increase the tolerance to low soil pH and mixed-sward compatibility of **lucerne** • Selection of shorter-season **medics** with better seed production and **sub clovers** with greater consistency across variable seasons
	Phalaris	• Selection to reduce phalaris toxicity and increase aluminium tolerance
	Subtropical species	• Selection of legumes for better adaptation to sub-tropical grass pastures • Selection of Subtropical grasses for adaptation to southern Australia
Pasture Production	Pasture nutrition	• Improve the efficiency of fertilizer use by better testing and application regimes and better harnessing of soil biological processes.
Pasture Management and Harvest	Grazing management	• Develop grazing systems for better utilisation of pastures and shrubs, which encourage perenniality, achieve high livestock performance with high labour efficiency.
	Pasture management	• Develop information to allow management of pastures to fill feed gaps for increased persistence, quality and productivity in a variable climate.
		• Develop more labour efficient approaches to sheep production
Production Systems	Integration of crops, pastures and livestock	• Develop systems for better integration of livestock and the pastures that support them with cropping enterprises. Primary attention to the role of grazing cereals, legume break crops and the strategic use of containment feeding.
Evaluation	Farm system models and financial benchmarks	• Further develop models that will assist with climate adaptation, financial performance and system optimization.

[1] The research component of the FIP is included in this report as Appendix A, and the full report is available from MLA.

To assist the process, the MLA Board provided the following guidance to management to finalise the plan:

1. The next phase in developing the FIP requires the development of individual projects, greater detail in budgets, an open call to attract novel ideas, negotiation with other RDCs, testing in a logical framework against key quantifiable objectives and a rigorous benefit-cost analysis for the program before funding can be considered.
2. The FIP development will be undertaken in two stages to complete the 6 research programs outlined in Figure 1. Stage 1 develops content in Pasture Breeding & Evaluation (PBE), Pasture Agronomy & Management (PAM), and Grazing Management & production Systems (GMS), while Stage 2 develops content in soils, weeds & biodiversity and decision tools (modelling), to be incorporated when Stage 1 processes are completed.
3. Each research theme is to be well reviewed in terms of what we already know, what are the gaps and opportunities for new R&D. The target is innovative producers who have already adopted "best practice pasture management" and want to go further. The clear message is to identify and develop "next generation" Management Practices and work with leading producers to evaluate potential to lift productivity and maintain/improve natural resources.
4. Each program must build a comprehensive pipeline of feedbase RD&E – ie from strategic research, through applied research and development and with strong links to delivery.
5. Ensure there are clear quantifiable objectives for the program, a sound business case for investment and logical justification for all components.
6. Proceed with caution with National Variety Testing and improving pasture seed supply chains, and concentrate on species where market failure exists
7. A longer term investment horizon can be considered provided it is supported by sound business case and appropriate review decision points.

Figure 1 – The six feedbase research themes that require development of project level content.



The Red Meat Co-investment Committee's pastures sub-committee supported the proposed approach based on consultants working with the research organisations to collate project level detail, within priority areas identified in the consultation

The Call for Project Proposals

MLA appointed Warren Mason to oversee the next stage of FIP development, assisted by Development Coordinators - Kevin Smith (Pasture Breeding & Evaluation - PBE), David Hudson (Pasture Agronomy & Management - PAM) and Lewis Kahn (Grazing Management & Systems - GMS).

A template for project proposals was developed, customised for PBE, PAM and GMS and sent out widely to research groups. As an example, the PBE template is attached at the end of this appendix.

Pasture Breeding & Evaluation - PBE
From the FIP (see Appendix A), the following framework for projects was developed to guide PBE project development.

***Research Objective**:*
Improved pasture choices available for meat producers in Southern Australia.

Deliverables:

1. Uniform and independent genetic evaluation (including persistence) and demonstration of pastures species and varieties for all regions other than the arid interior.
2. Improvement in the base pasture traits identified as important to meat producers – viz persistence, forage production quality and timeliness, P efficiency, seedling vigour and animal health outcomes;
    - Pasture legumes with the additional features of tolerance to low pH, performance in mixed swards and adapted to shorter/more variable seasons and sub-tropical regions;
    - Pasture grasses with the additional features of reduced toxicity, better aluminium tolerance and adaptation to variable seasons and sub-tropical regions.
3. Tools and processes to assist meat producers and service providers access and utilise the most suitable pasture genetics

These deliverables are applicable to all agro-ecological regions other than the arid interior.

Pasture Agronomy & Management - PAM
From the FIP (see Appendix A), the following framework for projects was developed to guide PAM project development.

***Research Objective**:*
Development of new tools and technologies to better manage the pasture feedbase to improve profit, productivity and sustainability

Deliverables:

1. Improved pasture nutrition through a combination of increased soil fertility, and/or fertiliser precision, and/or soil biological processes.
2. Increased content of desirable species and increased consistency of legumes in pastures.
3. Reduced incidence of and impact from, weeds and other biotic and abiotic stresses in pastures.
4. Pasture management tactics that improve pasture persistence, productivity and quality and that address feed gaps and seasonal variability.
5. Tools and processes to assist meat producers and service providers increase pasture performance.

These deliverables are applicable to all agro-ecological regions except that deliverable 1 does not apply to the arid interior.

Grazing Management & production Systems - GMS
From the FIP (see Appendix A), the following framework for projects was developed to guide GMS project development.

***Research Objective**:*
Grazing systems that better utilise pastures and shrubs; encourage perenniality; increase livestock performance; increase labour and resource use efficiency, and deliver environmental outcomes.

Deliverables:

1. Grazing rotation indicators and trigger points for matching stocking rates and pasture utilisation goals across different systems and regions to increase profit and deliver NRM benefits
2. Development/evaluation of the impact of grazing strategies and pasture utilisation on livestock performance, risk, profit and sustainability
3. Integration of livestock/pastures, and cropping to increase business profit and reduce risk
4. Evaluation of the strategic role of fodder conservation and containment feeding in mixed farming systems
5. Tools and processes to assist meat producers and service providers improve grazing management/systems

Deliverables 1, 2 and 5 are applicable to all agro-ecological regions. Deliverables 3 and 4 are particularly focussed on those agro-ecological zones where mixed farming predominates – ie the temperate slopes & plains, the sub-tropical slopes & plains, and the semi-arid tropical/subtropical plains.

Guidelines for completing the attached 'Indicative Project Proposal' template

1. MLA (on behalf of the Red Meat Co-investment Committee - RMCiC) has commissioned the development of a "Feedbase Investment Plan" or FIP. Copies are available from the Development Coordinator (see below). The FIP involved extensive industry consultation and has resulted in three research program areas (ie Plant breeding and evaluation, Pasture agronomy & management, and Grazing management & production systems) for immediate progression. The research objectives and deliverables for 'Plant breeding & evaluation' are shown below (see diagram). The task now is to develop project proposals that can be aggregated into a comprehensive program of work.

2. MLA (on behalf of the RMCiC) has appointed a 'Development Coordinator' as the key contact person for pasture plant breeding & evaluation projects – **Kevin Smith (KSmith@abacusbio.com.au, Ph 03 5578-7277, Mob 0408 350 478)**. All individuals or groups planning to submit a project proposal using the attached template should contact Kevin and discuss the project/process with him before filling in the template.

3. All sections must be completed but must not exceed 3 pages using the preset margins and font

4. These guidelines, the program diagram (showing research objectives, deliverables and indicative projects) and the descriptive text in the template (*in italics*) should be removed.

5. MLA is seeking to build a comprehensive pipeline of feedbase RD&E – ie from strategic research, through applied research, development and delivery. This means that while all projects will be considered, where appropriate preference will be given to projects that:
    - demonstrate a strong understanding of the challenges facing the red meat feedbase across southern Australia;
    - demonstrate a sound/innovative approach to the initiation and delivery of RD&E in the red meat industry and sound project management arrangements;
    - involve individuals/teams with a strong track record of delivery;
    - demonstrate real collaboration across organisations and agro-ecological regions during the project development process (and a strong willingness to collaborate/integrate during on-going project development and delivery if the project is approved by MLA);
    - are designed with the required partners in both capacity and geographic spread to address the industry issue and with clear linkages to the proposed target audience(s) and a likely path to market;
    - include (or link with) complementary areas of scientific research, including strategic science and/or more delivery focussed projects as appropriate;

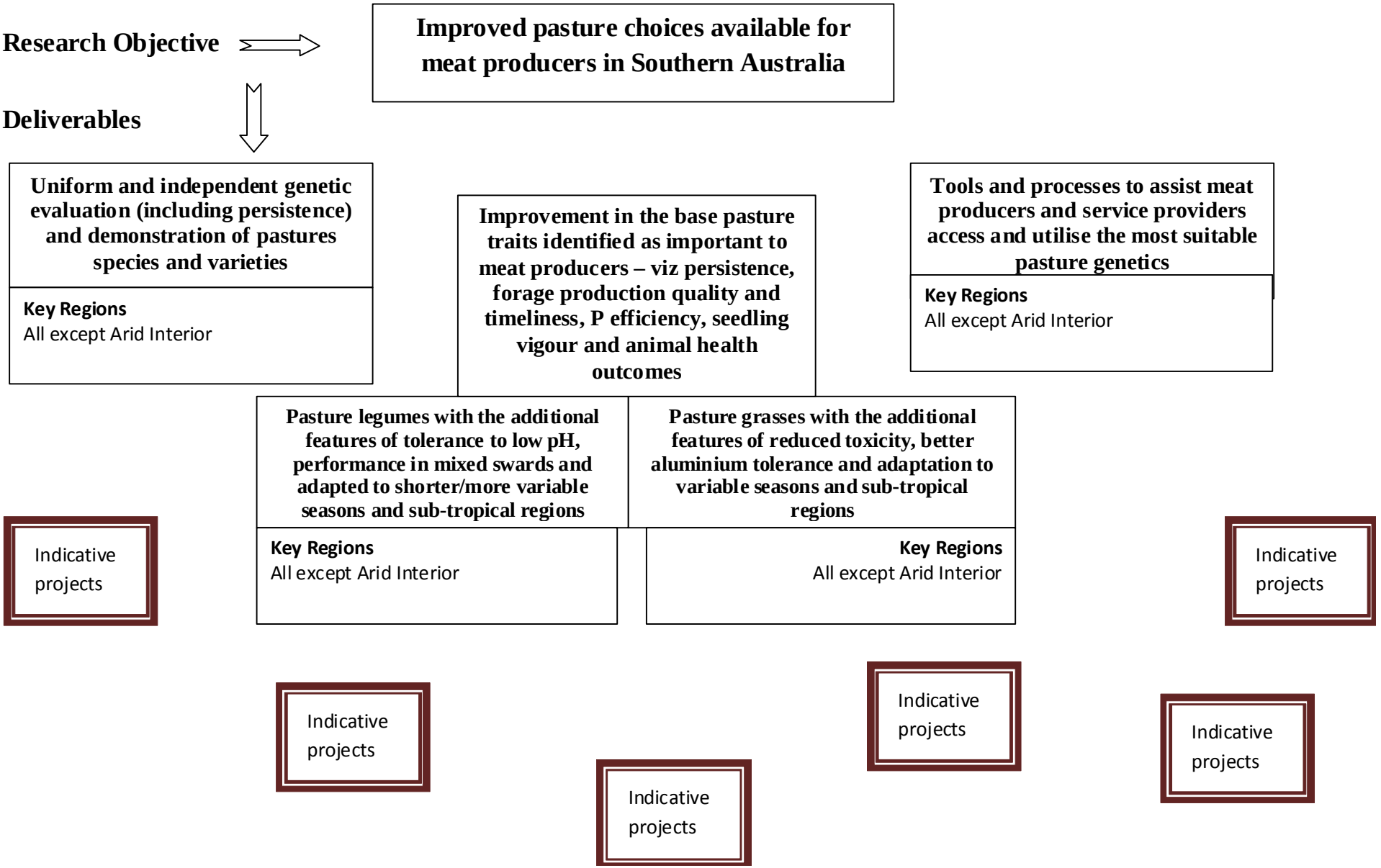
6. contribute to positive outcomes must be with Kevin Smith by COB 18 March 2011.
    - for NRM (eg soil, water, biodiversity, GHG), and for labour and resource use efficiency;
    - develop from best practice management of the best plants and the best animals;
    - incorporate stretch – MLA is seeking projects that will deliver significant improvements in the productivity and sustainability of red meat production.

7. All proposals for projects (completed templates), If the suite of proposed projects does not (as assessed by MLA and the RMCiC) deliver an adequate pipeline of RD&E activities, MLA will make a more specific project call to fill identified gaps, or directly commission projects.

8. The project proposals will be aggregated into a program of work by Kevin Smith (and project proponents) for submission to MLA and to RMCiC. MLA will undertake BCA across and within

program areas and put a package to their Board for a funding allocation. Once funding is secured, the projects will be finalised, integrated into a program and contracted – this next level of development will begin in July.

PROGRAM AREA – Pasture Plant Breeding & Evaluation



TEMPLATE FOR PASTURE PLANT IMPROVEMENT AND EVALUATION

PROJECT TITLE: *(short but descriptive)*

Classification; *Select from Strategic Science; Applied Science; or Delivery*

This project is focussed on delivering: *(What will be delivered, and to whom?)*

-

Objective(s) (SMART): *(What are the specific, measurable, achievable etc objectives of the project?)*

-

Researchable question(s): *(What are the specific questions the project is designed to answer?)*

-

Likely methodology / Indicative Design:

Outputs: *(What will the project actually 'produce' and who will these outputs be useful to?)*

-

Benefits: *(objective description of the proposed benefits (productivity, profit, sustainability, tangible and intangible) from the project and the scale of those benefits - might include No of producers, ha covered, pasture/livestock production gains (objective), costs decreased (how much), NRM benefits etc***)**

-

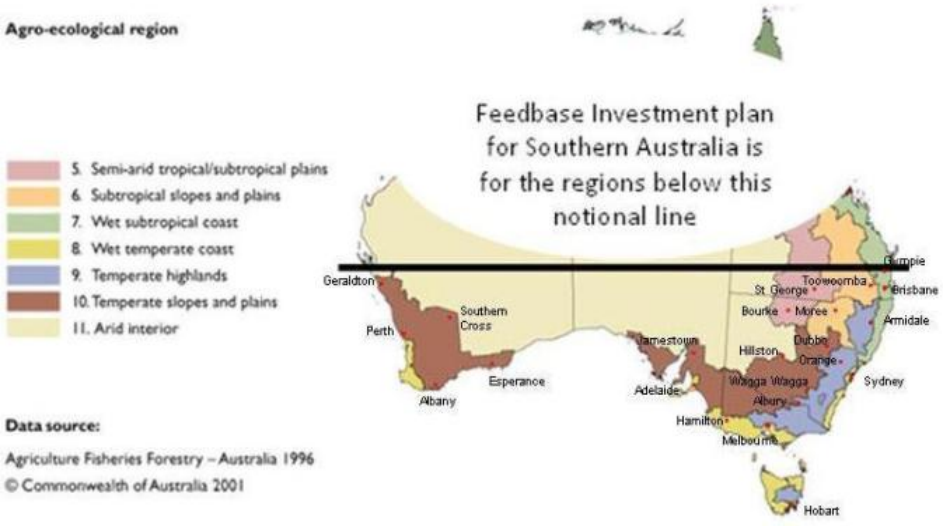
What else is required to deliver the benefit to the target end/next user *(tools, processes, extension, etc)*

-

Potential project team:

Leader: *(Organisation and roles; Research staff and function)*
Partner(s): *(Organisation and roles; Research staff and function)*

Agro-ecological region(s): *(Which A-E regions benefit from the project. Delete map when filling in the template)*



-

Potential locations: *(Where will the project activities take place?)*

-

Proposed start date:
Proposed project duration:

Indicative cost:

Estimated MLA contribution	Estimated cash and in-kind contributions from partner organisations	Estimated cash/in-kind contributions from 3rd parties	Total

Evidence: *(Brief overview of the 'evidence' that you believe makes this project an essential component of the MLA feedbase program and that you/your team are best placed to undertake it)*

Appendix F

Report on Plant Breeding and Evaluation Project Review

MLA Feedbase Project Review Workshop
MLA North Sydney
29th and 30th March 2010

Dr Kevin Smith
Abacus Bio Pty Ltd
April 2011

Executive Summary

Recommendations

Therefore the MLA Feedbase Project Review Workshop recommended that the following actions occur in the area of Plant Breeding and Evaluation:

Evaluation

1. ***Further consultation between MLA and the proponents of PBE22 to develop a broader and more robust evaluation based on many of the attributes of PBE22.***

2. ***That approximately $500k per annum of MLA funds be allocated to the evaluation theme subject to negotiations in Recommendation 1, co-investment and benefit:cost analysis***

Existing Breeding Programs

3. ***Further consultation between MLA and the proponents of PBE24 to develop a broader project based on many of the attributes of PBE24 but with a much greater emphasis on the delivery of this new rhizobiology methodology to breeding programs.***

4. ***That approximately $400k per annum of MLA funds be allocated to the project described in Recommendation 3 subject to negotiations on the issues raised by the Feedbase Project Review, co-investment and benefit:cost analysis.***

5. ***That the proponents of projects PBE2, PBE6, PBE14, PBE18, PBE26 and PBE33 be advised of the MDC model for investment and be encouraged to consider this model for co-investment in these projects.***

Novel Species

6. ***MLA advise proponents of projects on novel species of the need to develop a skilled and realistic assessment of the likely benefits and risks associated with these species before requesting funds for further development. MLA may consider co-investment in this market analysis subject to perceived demand.***

Traits and technologies

7. ***MLA negotiate with the proponents of PBE10 on phalaris toxicity regarding the potential revision of this project prior to contracting.***

8. ***That approximately $300k per annum of MLA funds be allocated to the project described in Recommendation 7 subject to negotiations on the issues raised by the Feedbase Project Review, co-investment and benefit:cost analysis.***

9. ***That MLA develop and commission a project to further develop and refine economic indicators and indices in pasture plants including the thorough assessment of the opinions of leading producers with an indicative budget of up to $200k pa for 2 years.***

10. ***That MLA commission a workshop or workshops and associated activities to develop a list of priority traits in pasture grasses and legumes of primary importance to Australian meat producers and following the success of these workshops commission project development activities to address the highest priority traits with an indicative MLA budget of $300 – 500k pa.***

11. ***That MLA review the activities in genomic selection in plants and animals and define the priority areas (species or technologies) for MLA investment in this area to ensure that advances in genomic selection of forages are of relevance to Australian meat producers.***

Background

Following a review of investment priorities for Feedbase Research and Development (MS&A 2011), Meat and Livestock Australia (MLA) issued an open call for indicative research proposals in three research program areas: Plant Breeding and Evaluation, Pasture Agronomy and Management and Grazing Management and Production Systems.

Dr Kevin Smith of AbacusBio Pty Ltd was contracted by MLA to manage the bid process for MLA for Plant Breeding and Evaluation Projects in the role of Development Co-ordinator (DC), specifically

- Develop and review templates for project submission, refereeing and review in conjunction with other DCs, MLA and the project leader
- Call for projects from parties in the private, public and academic sectors
- Provide a point of contact and initial advice to project proponents
- Receive and collate indicative projects as submitted by project proponents
- Facilitate the Plant Breeding and Evaluation component of the MLA Feedbase Project Review Workshop
- Prepare a narrative that describes the current status of pasture plant breeding and evaluation research in Australia as background information for the members of the MLA Feedbase Project Review Workshop.

The following is an extract from the MLA call for project submissions that describes the requirements of MLA for projects in this area:

MLA is seeking to build a comprehensive pipeline of feedbase RD&E – ie from strategic research, through applied research, development and delivery. This means that while all projects will be considered, where appropriate preference will be given to projects that:

- *demonstrate a strong understanding of the challenges facing the red meat feedbase across southern Australia;*
- *demonstrate a sound/innovative approach to the initiation and delivery of RD&E in the red meat industry and sound project management arrangements;*
- *involve individuals/teams with a strong track record of delivery;*
- *demonstrate real collaboration across organizations and agro-ecological regions during the project development process (and a strong willingness to collaborate/integrate during on-going project development and delivery if the project is approved by MLA);*

- *are designed with the required partners in both capacity and geographic spread to address the industry issue and with clear linkages to the proposed target audience(s) and a likely path to market;*
- *include (or link with) complementary areas of scientific research, including strategic science and/or more delivery focussed projects as appropriate;*
- *contribute to positive outcomes for NRM (eg soil, water, biodiversity, GHG), and for labour and resource use efficiency;*
- *develop from best practice management of the best plants and the best animals;*
- *incorporate stretch – MLA is seeking projects that will deliver significant improvements in the productivity and sustainability of red meat production.*

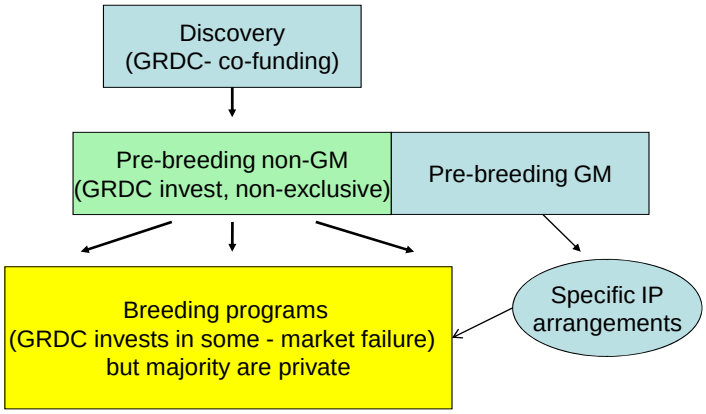
A total of 39 indicative projects targeting Plant Breeding and Evaluation were received from project proponents that covered a broad range of areas across regions, species and scientific areas. In order to better aggregate and review these projects the MLA Feedbase Project Review Workshop resolved to group the projects in four thematic areas:

- *Evaluation (9 projects)*
- *Species with Existing and Active Breeding Programs (12 projects)*
- *Novel Species (3 projects)*
- *Traits and Technologies (13 projects)*

A further 2 projects (PBE3, PBE27) were considered to be largely focused on extension or adoption activities and were hence outside of the scope of this call and were referred to MLA for consideration in a future call for Extension and Adoption projects in the Feedbase area. During the review of projects a further two projects were identified as being more suitably reviewed as part of other MLA initiatives (PBE23 as part of the future soils initiative and PBE 37 as part of the Grazing Systems Group at this MLA Feedbase Project Review Workshop). Further information on the outcomes, critical success factors and project development activities for each of the themes are listed below.

The workshop also believed that there was merit in the investment model that has been implemented by PISC agencies and GRDC being considered when investing in pasture plant breeding (see diagram below). In this model industry levies (and PISC agency investments) are concentrated on the discovery and pre-breeding stages of the R&D pipeline. Many of the pre-breeding activities are funded and designed to ensure that novel traits and technologies are made broadly available to breeding programs.

Grains model:



Plant Breeding and Evaluation Thematic Areas

Evaluation

Outcome Statement:
Australian meat producers are able to increase productivity and profitability by 10% through making informed choices on pasture technologies based on robust and accurate description of these technologies against key drivers of profitability and productivity.
Definition:
This theme covers those projects that seek to evaluate forage cultivars, species or technologies for adaptation and/or performance in Australian environments or production systems.

Desirable features of projects in this area

- Independence and robustness of data
- When can you evaluate? Commercial and/or pre-commercial? Desire to "jump start" the process to get information to leading producers quickly with estimates on the reliability of this early data.
- Must fit in with existing/proposed National Variety Trial process and add value to it.
- Need to measure animal performance, persistence and mixed swards appropriately.
- Need better and focussed assessment of economic indicators.
- Include "off-the-shelf" varieties; that are available but not widely used to better assess their potential and thereby avoid further unnecessary breeding efforts.
- Linkage with top producers to better address their information needs.

***General submitted projects from the* MLA Feedbase Project Review Workshop**

- Several projects had a regional focus with no linkages outside of the region. Whilst regional data is important it is of most value when protocols and data are shared across regions.
- Several projects did not extend existing protocols and hence were not addressing research needs but rather were about the extension and adoption of existing cultivars.
- There was a wide variation in the cost per site of activities that appeared similar in focus.

Recommendations

Whilst none of the projects submitted were viewed to suitable for immediate contracting, the MLA Feedbase Project Review Workshop assessed that the project PBE22 went closest to addressing the requirements in this area based on the prior assessment of the MLA Feedbase Project Review Workshop members and subsequent discussion. PBE22 was assessed to have many desirable features such as:

- Broad spread of trial sites
- Desire to include nutritive value and persistence (although the workshop did not believe that the proposed duration would adequately assess persistence)
- Project team experienced in this area of science including pasture trials and nutritive value analysis
- An initial inclusion of cultivars from multiple companies and the inclusion of historical standards to allow an estimate of genetic gain

Therefore the MLA Feedbase Project Review Workshop recommended that the following actions occur in this area:

1. ***Further consultation between MLA and the proponents of PBE22 to develop a broader and more robust evaluation based on many of the attributes of PBE22.***

This consultation should address the following issues to the satisfaction of MLA:

- Ability to include germplasm from further companies and trial co-operators from other locations
- Extension of the project to allow an adequate measure of persistence
- The development of an agreed protocol for persistence measurement
- Ensuring linkages to company sites and research sites to allow data aggregation and analysis

2. ***That approximately $500k per annum of MLA funds be allocated to the evaluation theme subject to negotiations in Recommendation 1, co-investment and benefit:cost analysis***

Species with Existing Breeding Programs

Definition:

This theme covers those projects that seek funding for species that currently have existing breeding programs. The breeding programs may be in the private or public sector (or in partnership) and the species may either have broad usage (such as perennial ryegrass or lucerne) or be more focussed on specific environments or production systems (eg red clover, chicory).

Outcome Statement:
Australian meat producers are able to increase productivity and profitability by 15% through the more rapid breeding of cultivars and the incorporation of novel traits and attributes into these cultivars.

Desirable features of projects in this area
- Projects should focus on improving the breeding process: ie breeding better and faster.
- Regional priorities should be addressed.
- Projects should not duplicate activities of the commercial breeding sector.
- Where MLA funds for cultivar development are sought there should be a thorough gap analysis to identify sources of market failure and propose methodologies for addressing them.
- Projects should incorporate novel traits of importance to meat producers.

General submitted projects from the **MLA Feedbase Project Review Workshop**
- Several projects were focussed on developing replacements for existing cultivars or species without a proper market assessment of the needs for these replacements.
- Several projects were focussed on funding routine breeding projects and hence the rationale for investment of MLA levy funds was unclear.
- Several projects were focussed on developing cultivars of potential value for meat producers but the activities were very close to market and based on existing activities, these projects are recommended for consideration of investment through the MLA Donor Company (MDC) model where a thorough commercial and market analysis will be undertaken.

Recommendations

Whilst none of the projects submitted were viewed to suitable for immediate contracting, the MLA Feedbase Project Review Workshop assessed that the project PBE24 went closest to addressing the requirements in this area based on the prior assessment of the MLA Feedbase Project Review Workshop members and subsequent discussion. PBE24 was assessed to have many desirable features such as:
- Broad applicability across pasture legumes
- Addresses a key need of leading producers incorporating pasture legumes in grazing systems
- Project team experienced in this area of science

Therefore the MLA Feedbase Project Review Workshop recommended that the following actions occur in this area:

3. ***Further consultation between MLA and the proponents of PBE24 to develop a broader project based on many of the attributes of PBE24 but with a much greater emphasis on the delivery of this new rhizobiology methodology to breeding programs.***

This consultation should address the following issues to the satisfaction of MLA:
- Ability to extend the methodologies to all legume programs

- Increased focus on the incorporation of the methodologies into breeding programs rather than Rhizobiology *per se.*
- Ensuring use of breeding sites and research sites to allow data aggregation and analysis and testing of the suitability of the methodology across regions with contrasting *Rhizobium* populations.

4. ***That approximately $400k per annum of MLA funds be allocated to the project described in Recommendation 3 subject to negotiations on the issues raised by the Feedbase Project Review, co-investment and benefit:cost analysis.***

5. ***That the proponents of projects PBE2, PBE6, PBE14, PBE18, PBE26 and PBE33 be advised of the MDC model for investment and be encouraged to consider this model for co-investment in these projects.***

Novel Species

Definition:
This theme covers those projects that seek to develop novel forage cultivars or species for adaptation and/or performance in Australian environments or production systems. Generally there will be no history of breeding programs for these species or the programs have been discontinued for some time.

Outcome Statement:
Australian meat producers are able to increase productivity and profitability by greater than 15% in certain parts of their business through the incorporation of novel species into their feedbase.

Desirable features of projects in this area
- Projects should focus on species that complement the current feedbase systems.
- Regional priorities should be addressed.
- Projects should include a skilled and realistic market assessment that addresses the following features before development activities commence
    - Market need
    - Fit with existing grazing systems
    - Realistic uptake and adoption
    - Likely antiquality factors
    - Weediness assessment
    - Likely route to market

***General submitted projects from the* MLA Feedbase Project Review Workshop**
- Projects did not adequately address the role of these species for top producers, their likely fit with existing systems or provide an adequate market assessment.

Recommendations

None of the projects submitted were viewed to be suitable for contracting.

6. ***MLA advise proponents of projects on novel species of the need to develop a skilled and realistic assessment of the likely benefits and risks associated with these species before requesting funds for further development. MLA may consider co-investment in this market analysis subject to perceived demand.***

Traits and Technologies

Definition:
This theme covers those projects that seek to develop new traits or technologies for incorporation into breeding programs (these may be tools for better measurement of genetic potential; or better definition of traits such as persistence through the development of tools (molecular markers, DNA sequencing or screening methodologies for genetic variation for root production as an example). Generally, it is desirable that these traits and technologies made available to breeding programs in a way that maximises the delivery of novel genetic variation and genetic gain to Australian meat producers.

Outcome Statement:
Australian meat producers are able to increase productivity and profitability by greater than 15% in through the incorporation of greatly improved cultivars into their feedbase.

Desirable features of projects in this area
- Projects should focus on traits of importance to meat production or tools that greatly enhance the rate of genetic gain in forage species.
- The emphasis should be on those traits and technologies that are likely to provide a step-change in productivity or profitability from pastures.
- Projects should include a realistic assessment of the likelihood of success, acknowledging that for many project in this area there is an association between risk and reward.
- Projects should articulate likely issues regarding route to market even if these are not fully resolved.

***General submitted projects from the* MLA Feedbase Project Review Workshop**
- Projects did not adequately address the role of chosen traits in providing advances in meat production or the relative value of these traits relative to other opportunities.
- In some cases large investments in traits and technologies were sought before more basic issues were addressed. For instance applying genomic technologies in species for which there were no current markets and basic issues regarding agronomy to be addressed or large scale data analysis programs that appeared to be out of scale with the amount of data currently available.

Recommendations

None of the projects submitted were viewed to be suitable for direct contracting. However, the MLA Feedbase Project Review Workshop saw this area as an important area for investment to enhance the rate of genetic gain for pastures and the relevance of new pasture technologies for leading meat producers and recommended that 4 areas proceed as a result of this workshop.

7. ***MLA negotiate with the proponents of PBE10 regarding the potential revision of this project prior to contracting.***

This consultation should address the following issues to the satisfaction of MLA:

- Thorough market analysis of the impact of phalaris toxicity across regions.
- The likely market use and adoption of a phalaris toxicity assay/indicator.
- The potential of the science expertise proposed to be funded by MLA to be used to address other issues of pasture toxicity and other teams in this area (eg the team at CSU in Wagga).

8. ***That approximately $300k per annum of MLA funds be allocated to the project described in Recommendation 7 subject to negotiations on the issues raised by the Feedbase Project Review, co-investment and benefit:cost analysis.***

9. ***That MLA develop and commission a project to further develop and refine economic indicators and indices in pasture plants including the thorough assessment of the opinions of leading producers with an indicative budget of up to $200k pa for 2 years.***

This project should address the following issues to the satisfaction of MLA:

- The further development of breeding objective methodologies for pasture species that have been developed by MLA to allow the assessment of the economic value of pasture innovations across regions and grazing systems.
- The linkage of these activities with those proposed by other agencies such as DA and DFCRC.

10. ***That MLA commission a workshop or workshops and associated activities to develop a list of priority traits in pasture grasses and legumes of primary importance to Australian meat producers and following the success of these workshops commission project development activities to address the highest priority traits with an indicative MLA budget of $300 – 500k pa.***

This workshop should address the following issues to the satisfaction of MLA:

- The assessment of priority traits by region and species and the likely economic importance of these traits including the development of tools for ongoing assessment of these issues.
- The technical feasibility of achieving outcomes for the key traits of interest and thereby an assessment relative importance of the traits based on likely impact and feasibility of success.
- The development of tools and mechanisms to make these traits broadly available to breeding programs targeting the needs of Australian beef producers.

11. ***That MLA review the activities in genomic selection in plants and animals and define the priority areas (species or technologies) for MLA investment in this area to ensure that advances in genomic selection of forages are of relevance to Australian meat producers.***

Appendix G

Feedbase Project Review Workshop Report

Pasture Agronomy & Management

April 2011

Table of Contents

3.0 Background

In 2010, MLA on behalf of the RMCiC commissioned the development of a FIP for research, development and extension to underpin the productivity and profitability of red meat production from the southern Australian feedbase.

Following a review of the FIP outcomes by MLA three research platforms were identified as the basis for MLA's Feedbase R & D investment program:

1. Plant breeding and evaluation,
2. Pasture agronomy & management, and
3. Grazing management & production systems.

Following the establishment of the R & D platforms, invitations were sent by each platform co-ordinator to a list of public and private sector research providers, generated by MLA and the co-ordinator. Within the Pasture Agronomy & Management platform invitation's to submit R & D projects were sent to 62 research providers. In a number of situations the invitation was then re-directed to a broader group of potential research collaborators. The invitation to submit research proposals included the following MLA criteria to consider in developing project proposals:

MLA is seeking to build a comprehensive pipeline of feedbase RD&E – i.e. from strategic research, through applied research, development and delivery. This means that while all projects will be considered, where appropriate preference will be given to projects that:

- *demonstrate a strong understanding of the challenges facing the red meat feedbase across southern Australia;*
- *demonstrate a sound/innovative approach to the initiation and delivery of RD&E in the red meat industry and sound project management arrangements;*
- *involve individuals/teams with a strong track record of delivery;*
- *demonstrate real collaboration across organizations and agro-ecological regions during the project development process (and a strong willingness to collaborate/integrate during on-going project development and delivery if the project is approved by MLA);*
- *are designed with the required partners in both capacity and geographic spread to address the industry issue and with clear linkages to the proposed target audience(s) and a likely path to market;*
- *include (or link with) complementary areas of scientific research, including strategic science and/or more delivery focused projects as appropriate;*
- *contribute to positive outcomes for NRM (e.g. soil, water, biodiversity, GHG), and for labour and resource use efficiency;*
- *develop from best practice management of the best plants and the best animals;*
- *incorporate stretch – MLA is seeking projects that will deliver significant improvements in the productivity and sustainability of red meat production.*

The nominated sub-program areas and priorities for the Pasture Agronomy and Management platform or R & D projects were nominated as follows:

Pasture Agronomy and Management Sub-program R & D Priorities

Pasture Health	Improved pasture nutrition through a combination of increased soil fertility, and/or fertiliser precision, and/or soil biological processes
Pasture Composition	Increased content of desirable species and increased consistency of legumes in pastures
Pasture Maintenance	Reduced incidence of and impact from, abiotic and biotic stresses in pastures.
Pasture Management	Pasture management tactics that improve pasture persistence, productivity and quality and that address feed gaps and seasonal variability.
Productive Pastures	Tools and processes to assist meat producers and service providers increase pasture performance.

MLA received sixty one (61) R & D project proposals from public and private sector research providers for the Pasture Agronomy and Management platform. The proposals included a range of collaborations between state and Federal agencies and a limited number of public – private sector research collaborations.

For the purpose of the evaluation process at the workshop the nominated sub-programs were consolidated into three working themes. The allocation of the projects by theme and by agro-ecological zone is presented in the following table.

Pasture Agronomy & Management Theme	**Projects Submitted**	**Agro-ecological Zone**	**Projects Submitted***
Nutrient Balance	18	Semi-arid Tropical & Sub Tropical Plains	9
Re-establishment and improvements to the productive capacity of the feedbase.	14	Subtropical Slopes and Plains	14
Pasture health, maintenance and productivity.	29	Wet Subtropical Coast	10
		Wet Temperate Coast	38
		Temperate Highlands	38
		Temperate Slopes and Plains	49
		Arid Interior	6

**** Project proponents may have nominated the application of project outputs to multiple agro-ecological zones.***

The project proposals received were predominantly focused on the traditional pastoral and grazing regions of the Wet Temperate Coast (38) and Wet Temperate Subtropical Coast (38) and the Temperate Slopes and Plains (49).

4.0 Evaluation Process and Outcomes

MLA convened a workshop on March 30 and 31 2011 to evaluate the R&D proposals against the research platforms, key themes and deliverables and outcomes that had been agreed by the workshop participants.

To assist the development of the evaluation process a background narrative was prepared by each of the platform coordinators. The purpose of the narrative was to provide:

i) the workshop participants with an overview of the key research themes within each platform that had been developed from the FIP report, and

ii) the context within which to identify and evaluate research and development investment opportunities for the Pasture Agronomy and Management platform.

In preparation of the narrative the following assumptions were made with regard to its structure and output.

- That well adapted, productive pastures that are well managed and utilized are major drivers in reducing the cost of production for beef and lamb in southern Australia.
- That objective information is needed to describe the value of new pasture agronomy and management innovations for the feedbase in southern Australian livestock production systems.
- That new pasture agronomy and management innovations have the potential to provide both incremental and step-change improvements in productivity and profitability of the leading livestock meat producers.
- That there needs to be an increase in the number of: i) multiple public: public agency and ii) public: private collaborations and/or partnerships as these relationships will be critical to success in generating investment and delivery of pasture agronomy and management innovations to leading livestock meat producers.
- That the outcomes of the process are directed towards the leading ("Top 20? %") beef and sheep meat producers across the agro-ecological zones of southern Australia.

Following a review of the narrative by the livestock producer participants, industry technical experts and two referees, the narrative for each respective platform has been refined to include changes proposed at the workshop. (Appendix One)

During the evaluation process projects were assessed on the basis of whether they were:

- suitable for progress (with or without modification) to the cost-benefit analysis phase of the process,
- suitable for consolidation with other project proposals (within or between themes) and subsequently referred to cost benefit analysis ,
- suitable for assessment by the MLA Donor Company program, or being
- not suitable for progression within the current process.

The following presents the outcomes from the evaluation workshop held on March 30 and 31 2011.

4.1 **Theme One: Nutrient Balance** - more efficient, effective and economic use of soil nutrients for pasture and livestock production.

Key Deliverables/Outcomes:

- A key driver for livestock producers is to achieve "more bang for the buck" invested in achieving nutrient balance within the soil.
- Livestock producers need to achieve improved access to nutrients which are currently locked up in the soil.
- An improved understanding and management of the relationships between nutrients (and interactions)
- Minimisation of soil nutrient losses from pastures (environmental and economic benefits)
- The introduction and adoption of "Precision Technology" to improve application of fertilizers (cost / benefit)
- The adoption of "zonal management strategies" – getting the most value from inputs of pasture (short and long term) and nutrients
- Reducing industry risk – Improve "P Security", by improving efficiency and reducing reliance on the continual application of "P".

Overview of Projects:

The theme of "nutrient balance" within the soil was identified as being the major theme for investment within the Pasture Agronomy and Management platform. Fertilizer is one of the major input costs for the grain and grazing industries and the uncertainty of ongoing supply and cost of raw materials used in manufacture combined with the issues relating to efficient application make it a high priority for research.

Workshop participants identified that without a "healthy soil" livestock producers cannot grow a "good pasture". Therefore projects submitted were evaluated on the basis of their contribution to achieving a "healthy soil" for pasture production.

Despite the priority of achieving a "healthy soil", in general, there was a lack of research projects (apart from phosphorus) addressing the more efficient, effective and economic use of key macro and micro nutrients which are required to achieve a "healthy soil" for pastures.

The majority of projects submitted within the nutrient balance theme were associated with phosphorus use in pastures. While being identified as a priority area for potential MLA investment the program of "P" related projects requires consolidation and prioritisation to direct limited funds to the highest priority projects that will deliver benefit to industry. With limited funds it is imperative that duplication in projects is removed and projects provide a greater focus on the delivery of targeted outcomes. As this is a major cross sector issue (wool, meat, crops, dairy) this requires significant effort and where appropriate collaboration between RDC's would be recommended in order to facilitate efficient and timely delivery of outcomes applicable to each sector.

While there has been a coordinated approach by MLA and CSIRO to identifying and addressing the current status and future role of phosphorus within soils generating pastures, the workshop considered that the impact of nitrogen and overall nutrient balance had not been adequately considered in any of the project proposals submitted.

Evaluation Outcome Statement:

Projects recommended to go forward within the nutrient balance theme are focused on identifying the factors which limit the supply and use of key soil nutrients such as nitrogen and phosphorus, and providing resolutions which will allow the more effective, efficient and economic use of these nutrients for pasture production.

Recommendations:

a) It is recommended that the project "*Optimising nitrogen (N) supply to grass based pasture systems (PAM 5)* progress to the cost/benefit analysis and approval phase of the MLA R & D investment Plan.

b) It is recommended that the current "Soils" program budget of $650 be reallocated into the Nutrient Balance theme in order to support

   a. the proposed consolidated "P" program per recommendation (e)
   b. the initiation of a similar program for "N", and
   c. the initiation of recommendation (d)

c) It is recommended that MLA establish a nationally coordinated research project focused on profiling the current "nutrient and health" status of the various soils supporting pasture and livestock production across the agro-ecological zones of southern Australian. Information recommended to be collected across multiple sites should include but not be limited to the following:

   a. Soil nutrient status of macro and micro nutrients;
   b. Profile of the pasture sward present, including impacts of biotic and abiotic stress e.g. root morphology and presence or absence of soil pathogens;
   c. Feedbase and livestock management practices

   The information collected and collated can be utilised to identify the key factors which are limiting pasture and livestock production and to prioritize future R & D investment.

d) It is recommended that the following projects be reallocated to the MLA Donor Company for assessment as a potential investment opportunity for MLA:
   a. *Novel fertilisers to improve phosphorus efficiency in pasture production systems (PAM 15),*
   b. *Using Novel Water-sensing Cross-linking Biopolymer Nano-composites to Increase Phosphorus Fertiliser Use Efficiency in Pastures (PAM 17)*

e) It is recommended that MLA facilitate a process which will consolidate the following projects into a sub-theme of "Improving the efficient, effective and economic use of phosphorus in Pastures". The outcome of the process being a limited suite of prioritized projects which can progress to the cost/benefit analysis and the approval phase of the MLA R & D investment Plan.

Project Code	Project Title	Project Proponent	Project Participants
PAM 7	*Assessing size, transfers and availability of accumulated soil organic and inorganic phosphorus pools to improve economic and environmental outcomes in WA pastures*	Dr. Mike Wong (CSIRO)	CSIRO, DAFWA, UWA
PAM 8	*Does root damage change the P-requirements of clover-based pastures?*	Prof. Richard Simpson (CSIRO)	CSIRO, SARDI, NSW I&I, DAFWA
PAM 9	*Phosphorus-efficient pasture systems*	Prof. Richard Simpson (CSIRO)	CSIRO, NSW I&I, DAFWA
PAM 10	*Biology of the turnover and use of stored soil phosphorus in pasture systems*	Dr. Gupta Vadakattu (CSIRO)	CSIRO, VIC DPI
PAM 11	*Enhanced phosphorus-use efficiency in subterranean clover by genetic manipulation*	Dr. Manny Delhaize (CSIRO)	CSIRO, DAFWA
PAM 12	*Increasing the bioavailability of organic phosphorus in pasture soils*	Dr. Alan Richardson (CSIRO)	CSIRO, Uni of Adel,
PAM 14	*The nature of soil organic phosphorus and fertilizer management strategies to modify rates and pathways of fertilizer P flux in pasture soils*	Dr. Ron Smernik (WAITE), Prof. Mike Mc Laughlin (WAITE)	WAITE, Uni of Adel., CSIRO
PAM 16	*Understanding the fate and transformation of applied P through organic P phases and how to manage P to increase plant use efficiency in high rainfall pastures in northern NSW*	Dr. Chris Guppy (UNE)	UNE, WAITE, CSIRO
PAM 54	*Use new and alternative pasture species to improve P use efficiency on soils with well characterized pools of phosphorus and carbon*	Guangdi Li (NSW I&I)	NSW I&I, Uni of Adel., CSIRO,

4.2 Theme Two: Re- establishment and improvements to the productive capacity of the feedbase (*including increased desirable species; pasture composition; summer feed gaps; mixed farming – role of pasture in the system)*

Key Deliverables/Outcomes:

- Focus on retention of legumes, less so than grasses
- New legume species that fit with permanent pastures or crop rotations
- Produce summer fodder
- Fix more N
- Get the mix right of grasses and legumes – new exciting combinations, new legumes and grasses. 70% effort on new; 30% on existing mix
- Use of monoculture crops as short term pasture to give a massive impact on establishing a new pasture. Pasture that has same / analogous effect of forage canola on wheat crop (radical ideas, take on the novel ideas) – break pasture crops to reduce disease
- Multiple benefits from novel ideas (e.g. new pastures (plantain) has reduced crutching costs for sheep or may reduce the incidence of footrot)

Overview of Projects:

The theme of "Re- establishment and improvements to the productive capacity of the feedbase" was identified as being a low priority theme for investment within the Pasture Agronomy and Management platform.

Workshop participants identified that there had historically been a significant investment in research associated with increasing desirable species; pasture composition and filling summer feed gaps. In general, there was lack of research projects within the theme that represented a significant "leap" in opportunity (i.e. "the wow" factor) for livestock producers. This was in part due to a number of the project proposals presented being viewed as "recycled" from other research programs or projects being adaptations of proposals that have previously been rejected.

In addition it was identified that a number of projects submitted were more directed towards extension of existing knowledge and tended to be more regionally specific in their focus rather than identifying where the project outcomes may be applied across a broader range of agro-ecological zones.

There were a number of projects relating to the use of "companion species" and/or "changing pasture composition " which were identified as being worthy of initial assessment through inclusion in a national herbage evaluation program (NVT). As such, the assessment of these projects should be included within the PBE platform and that following initial evaluation, future MLA investment in these species/cultivars could be reviewed based on performance and market opportunity.

Evaluation Outcome Statement:

Projects recommended to go forward within theme two are focused on delivering new species which are either compatible with current permanent pasture species and/or can deliver new pasture options for the expanding mixed farming regions of southern Australia.

Recommendations:

a) It is recommended that the following projects progress to the cost/benefit analysis and approval phase of the MLA R & D investment Plan:

   a. *New temperate perennial grasses for improved profitability and sustainability of red meat production in southern Australia. (PAM 35),and*

   b. *Improving Nutritive Value of Dual-Purpose Wheat in Mixed Farming Systems of Southern Australia (PAM 51)* progress to the cost/benefit evaluation and approval phase of the MLA R & D investment Plan.

b) It is recommended that the following projects submitted to the Pasture Agronomy & Management platform be consolidated with similar projects within the Plant Breeding & Evaluation platform into a national evaluation program focused on new species/ current species and companion species (i.e. NVT).

PBE Theme	PAM Theme	PAM Projects for Consolidation
Novel Species	**Re-establishment and improvements to the productive capacity of the feedbase**	*Getting the mix right – combining pasture species for production and NRM in the cropping zone of southern Australia. (PAM 18)*
		Integrating a new bloat safe perennial legume on-farm to replace the poor performance of existing legumes in perennial grass based pastures.(PAM 37)
		GreenFeed – optimizing green feed from new forages to extend growing seasons and improve lamb production and meat quality. (PAM 42)
		New options for the establishment of perennial grasses in lower rainfall environments. (PAM 55)
		An agronomic description and evaluation of the merit and management of alternative complementary perennial pasture species for South Eastern Australia. (PAM 57)

c) It is recommended that the following projects be reallocated to the MLA Donor Company for assessment as a potential investment opportunity for MLA:

a. *The development of Australian bred Perennial ryegrass cultivars suited to lower rainfall environments. (PAM 1)*
b. *Fodder beet a reliable, highly productive alternate forage crop option for beef and sheep meat production in Southern Australia? (PAM 13)*
c. *Improving Wheat-sheep zone pasture and whole farm system productivity via new legume varieties and technologies. (PAM 31)*

4.3 Theme Three: Pasture health, maintenance and productivity *(including reduced incidence / impact from biotic and abiotic stresses, tools and processes that assist producers/ service providers to increase pasture & livestock performance).*

Key Deliverables/Outcomes:

- Dealing with variable seasons including extremes in weather.
- The impact on pastures of applying insecticides in the cropping phase and removal of beneficial pasture insects - how long does it take to build up beneficial insect populations in a pasture phase and how can the populations of beneficial insects be enhanced for pastures?
- The industry needs new pasture attributes including new plants that have tolerance to abiotic and biotic stress. e.g. insect and drought tolerance
- Identify complimentary insects for pastures. E.g. the use of bee's to increase dry matter - 6 hives per 100 ha over the farm.
- Complimentary enterprises and management actions to address pasture production (nutrient cycling; grazing approach (timeliness /severity)
- Rhizobia – regional and species applications
- Multiple benefits from novel ideas (e.g. new pasture (plantain) plants that reduce crutching costs or reduce sheep susceptibility to footrot)

Overview of Projects:

The theme of "Pasture health, maintenance and productivity" was identified as being of medium priority for investment within the Pasture Agronomy and Management platform.

The nature of the theme is it that captures a diverse portfolio of research proposals which are aimed at improving pasture sustainability and livestock productivity. Workshop participants acknowledged that for a range of reasons (e.g. pasture health, lack of persistence, abiotic and biotic stress etc.) the majority of leading livestock producers were still not capturing the potential which exists within their pastures.

The extent of limiting factors which contribute to this sub-optimal performance of pastures and hence livestock, is reflected in the diverse scope of research projects nominated, which ranged from the use and characterization of rhizobia for legumes through to control of specific pests and the use of "precision technologies" for management of pastures, fertilizer application and livestock management systems.

Many of the submitted project proposals highlighted the need for a change in paradigm for pasture and livestock management from traditional management based on fence-lines to "whole farm" management of differing soils types and pastures (i.e. zones) in order to optimize the soil + water + pasture + livestock relationship and at the same time achieve increased optimization in the use and application of resources such as fertilizers.

While recognizing that the majority of livestock producers may already undertake zonal management in some situations (e.g. water ways, rocky outcrops etc.) the proposed paradigm shift is to adopt this approach on a whole farm basis.

To achieve effective "zonal management" a number of projects identified the need to develop precision technologies and tools for pasture systems.

Workshop participants identified that historically there had been a significant investment in research associated with the use and application of "precision technologies" in the cropping industry. In the absence of any definitive demonstration of its application in pasture and livestock management workshop participants were somewhat skeptical to the potential application in pastures. However, participants recognized that despite the costs associated with introduction and implementation, the adoption and use of "precision technologies" could lead to some significant improvements in pasture and livestock productivity.

Therefore, it was recommended that prior to MLA undertaking any significant investment in developing precision technologies for zonal management of pastures and livestock, a scoping and value proposition study needs to be completed. In addition it was identified that a number of projects submitted within the "Pasture health, maintenance and productivity" theme should be combined with projects embedded within the "Livestock system design" theme within the Grazing management Systems platform.

Evaluation Outcome Statement:

Projects recommended to proceed for further consideration are focused on specific issue management (i.e. insect control and rhizobia) or are alternatively focused on providing tools which will assist livestock producers in their "zonal management" of soils and pastures – the outcome of which will lead to more efficient, effective and sustainable use of feedbase resources (i.e. pasture, soil, water, manpower, fertilizer etc.).

Recommendations:

a) It is recommended that MLA allocate $450,000 (30%) of the proposed budget for the Pasture Agronomy and Management platform to the theme of "Pasture health, Maintenance and Productivity".

b) It is recommended that the following projects progress to the cost/benefit analysis and approval phase of the MLA R & D investment Plan:

a. *Biology and control of the pasture root aphid in Australia. (PAM 19), and*

b. *Rhizobia effectiveness and new approaches to nodulation in pasture legumes. (PAM 48)*

c) It is recommended that prior to investing in precision technologies for application and use in pastures, MLA commission a scoping study to :
   a. Evaluate (SWOT analysis) the use and application of precision agricultural technologies in mixed farming enterprises across a range of agro-ecological zones in southern Australia.
   b. Identify the current and future applications of precision agricultural technologies for "zonal management" of pastures, including identifying barriers to adoption; and
   c. Establish the likely costs and benefits (tangible and intangible) from adoption of various precision technologies in terms of their impact on pasture and livestock productivity, resource use and management practices.

d) It is recommended that subject to the completion of Recommendation (c) the following projects submitted to the Pasture Agronomy & Management platform be consolidated with similar projects within the Grazing Management Systems platform into a national project focused on the use of precision technologies for "Zonal management of pastures for more efficient, effective and sustainable use of feedbase resources".

GMS Theme	PAM Theme	PAM Projects for Consolidation
Livestock system design.	**Pasture health, maintenance and productivity:**	*Remote sensing of grazed landscapes: A tool for strategic management of livestock systems. (PAM 27)*
		Precision Agriculture for Pasture Management: Site Specific Management of Fertilizer in Grazing Systems. (PAM 28)
		Enhancing precision technologies for remote pasture and grazing management. (PAM 29)
		Increasing resource use efficiency, pasture production and pasture utilization through land class-targeted management in topographically variable landscapes. (PAM 53)

Appendix H

Feedbase Project Review Workshop Report

Grazing Management and Production Systems

April 2011

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Introduction

MLA (on behalf of the Red Meat Co-investment Committee - RMCiC) commissioned the development of a Feedbase Investment Plan from which three research program areas (i.e. plant breeding and evaluation, pasture agronomy and management, and grazing management and production systems) were selected for immediate progression. This document describes the call for grazing management and production systems proposals, the process used to determine priority proposals, and recommendations for research investment.

Project proposals

A call was made to industry in February 2011 to submit research proposals that met the identified objectives and key deliverables of the grazing management and production systems program. Applicants were asked to address the following issues:

- demonstrate a strong understanding of the challenges facing the red meat feedbase across southern Australia;
- demonstrate a sound/innovative approach to the initiation and delivery of RD&E in the red meat industry and sound project management arrangements;
- involve individuals/teams with a strong track record of delivery;
- demonstrate real collaboration across organisations and agro-ecological regions during the project development process (and a strong willingness to collaborate/integrate during on-going project development and delivery if the project is approved by MLA);
- are designed with the required partners in both capacity and geographic spread to address the industry issue and with clear linkages to the proposed target audience(s) and a likely path to market;
- include (or link with) complementary areas of scientific research, including strategic science and/or more delivery focused projects as appropriate;
- contribute to positive outcomes for NRM (eg soil, water, biodiversity, GHG), and for labour and resource use efficiency;
- develop from best practice management of the best plants and the best animals;
- incorporate stretch for leading producers– MLA is seeking projects that will deliver significant improvements in the productivity and sustainability of red meat production.

A total of 49 proposals were received for the grazing management and production systems program with some proposals being applicable to other program areas.

Feedbase Project Review Workshop

An industry workshop was held March 2011 to review the proposals from the three program areas. A full description of the workshop format is provided elsewhere (Mason 2011). In brief, a review was prepared to provide the background and industry context for future research and development with grazing management and production systems and to identify opportunities for research investment (see Appendix 1). The workshop refined the recommendations in the review and identified three key themes of interest requiring research and development.

The overarching goal of these themes is to increase profit by increasing the margin between cost of production and sales revenue. The role of research and development in grazing management and production systems is to optimise stocking rates through better managing pasture utilisation in concert with enterprise flexibility. These changes must improve labour efficiency, optimise legume content, produce agricultural systems that are resilient to climatic fragility, manage risk and meet market specifications.

The connectivity between program themes is outlined schematically in Figure 1. While much information is known about grazing management and production systems, it is the collection, interpretation and optimization of data in real time that acts as a barrier to change. There is still a need for collection of empirical data concerning the mechanics of grazing decisions and about the integration of out of season feeds (in temperate and subtropical regions), but this information needs to be accompanied by innovation in remote data collection and optimization procedures relevant for the farm business.

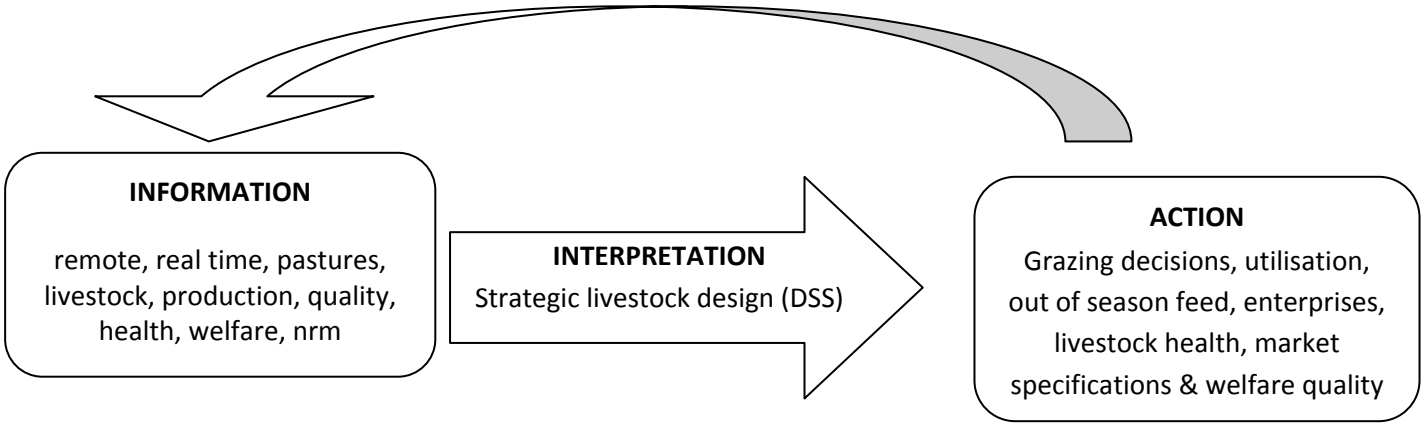


Figure 1: Schematic representation of required innovation and its application in grazing management and production systems.

The three themes supported within the grazing management and production systems program are:

Theme 1: Grazing and animal indicators

Remote digital collection of pasture and livestock performance to inform grazing and other management activities that optimise stocking rate, livestock and pasture performance and livestock health and welfare in consideration of target market specifications. Data collection needs to capture pasture and livestock performance in real time to inform decision support services in order to optimise the grazing system.

Theme 2: Integration of crops, shrubs, niche pasture species and containment feeding

Change the shape and benefits (pharmaceutical and nutritional) of the feed supply curve to alleviate nutrient restriction and permit enterprise fit (timing of activities and choice) that best matches regional market specifications. Impact from these feed sources needs to allow optimization of whole farm pasture utilisation and animal health and welfare and ensure nrm targets (such as ground

cover) are met. This theme includes the grazing of crops, shrubs and niche pasture species but also includes strategic use of containment feeding.

Theme 3: Livestock system design

Capture and interpret remote and local data to inform actions which optimise grazing and production systems in consideration of enterprise, market specification, risk exposure and complexity.

Recommendations

The 49 proposals were assessed through the workshop process to determine alignment with the program themes. Allocation of investment funds among the research themes is proposed as 55% for *Grazing and animal indicators*, 25% for *Integration of crops, shrubs, niche pasture species and containment feeding* and 20% for *Livestock system design*.

Theme 1: Grazing and animal indicators

A total of four proposals are recommended for further investigation with a total theme budget of $825K p.a. All projects will require considerable modification to accommodate greater collaboration and to link remote data collection innovations with empirical studies. This modification is required to meet the outcomes of the research themes. Of these proposals substantial modification is sought for GMS31 in ways that will focus this proposal more directly on the grazing management needs of subtropical swards and the persistence/maintenance of pasture legumes. The proposals were:

GMS29	Validate pasture productivity assessments of the PGR® model in Eastern Australia
GMS3	Improved decision making in grazing management to optimise animal production and enhance pasture composition
GMS43	Technology Based Shepherding (Remote sensing of sheep grazing behaviour and animal health for improved management, productivity and animal welfare)
GMS31	Filling feed gaps with tropical perennial grasses and tropical and temperate legumes in the red meat zone in southern Australia

Theme 2: Integration of crops, shrubs, niche pasture species and containment feeding

A total of three proposals are recommended for further investigation with a total theme budget of $375K p.a. One of these projects (GMS 12) is recommended with only minor modification and a technical review of GMS 22 is recommended to ensure the work is novel and warranted in a modified form. The other project (GMS 27) will require considerable modification to accommodate greater collaboration, a change or narrowing of research focus and reduced budget. The proposals were:

GMS12	Achieving a step change in HRZ livestock production by capitalizing on dual-purpose cropping
GMS22	Improved utilisation of the whole farm feedbase in the 'wheat sheep' zone to improve whole farm profit and positive NRM outcomes
GMS27	Profitable and resilient grazing systems with shrubs and pasture – 'Enrich' farming systems

Theme 3: Livestock system design

A total of two proposals are recommended for further investigation with a total theme budget of up to $300K p.a. One of these projects (GMS 10) is recommended for technical review to ensure the work is novel and warranted in a modified form. The other proposal (GMS 11) may play the integrating role for innovation in data collection from theme 1. The proposals were:

GMS10	Evaluation of the role for forage conservation and containment feeding in livestock grazing systems
GMS11	A web based tool for advisors and producers for analysing and improving pasture utilization in Australian grazing systems

Project realignment with program themes

A workshop is recommended to facilitate the process of realigning the nine proposals with the program themes. This will provide the opportunity for representatives from each proposal to contribute to the development process and for integration across themes. The organisation and conduct of the workshop will require careful development. The proposed program themes captured the opportunities identified in the review (Appendix 1) and the workshops will provide the means to ensure research delivery.

PISC agency Strategic requirements

The PISC agency partners comprise membership of the Red Meat Co-investment Committee (RMCiC). This includes NSW I&I, DEEDI, SARDI, DPI Victoria, DAFWA, TIAR, the University sector and CSIRO Plant Industries.

Capacity in the feedbase, retention of staff are two issues that future industry investment can assist to address. Expertise in PISC agencies is being diverted to other disciplines as agencies seek to adjust to budget cuts. Current deployment of expertise within the agencies is volatile and strongly influenced by government and industry policy. As a direct consequence PISC agencies presently in the middle of a substantial loss of skill across Australia as it applies to pasture based industries. Research organisations (federal and state research agencies and universities) budgets are all predicated on the existence of the shared investment model.

The following information reflects the strategic priorities of the partner PISC agencies in development of the feedbase plan.

Targeted Strategies

- Address capacity and retention of staff by participation in a collective development process
- Utilise research agencies with the capacity and capability to undertake the research. This enables “lead agencies” and “supporting: organisations as defined in the national R&D strategies

Assumptions and recommendations for the plan

The above outcomes assume that the following are required in the development and implementation of the portfolio:

- Based on prevailing circumstances (eg fragmented research base, public and private sector working in feedbase RD&E, delivery / adoption challenges etc) a change in the RD&E model in required
- Collective development of projects recognising the strategic intent, capacity and capability of the PISC organisations underpins the new business model
- Collective development aims to also address the primary livestock industry issues across the agro-ecological zones. This development will enable a critical mass of research and delivery effort, and by implications means larger programs of work as against regional projects.
- Maintenance and development of research capacity is a critical issue. Consultation data (see below) suggests broadly that there is sufficient research capacity in most feedbase components, in many cases, survey and interview respondents commented that the skill base is thin and in decline.
- As the decline in capacity is being driven by staff who are near retirement and there is no depth in the replacement pipeline, the feedbase portfolio should focus on building opportunities for new researchers via PhD scholarships and post docs , targeted at developing the candidates career path.
- More innovative approaches to research (especially in pasture persistence) is needed to overcome lack of adoption of technologies. This may be targeted at lowering costs, improving confidence in potential returns and reducing risk of failure
- Future work must address explicitly what has been done and justify required work
- Work from the FIP consultation, project call and MLA review workshop has provided the basic structure to progress. Further work is required in developing up the programs of work:
    - clustering like proposals
    - testing priority of the clusters with the PISC agencies
    - developing the regional proposals towards a common agro-ecological zone issue. This may be achieved by “challenge workshops” where producers and the project proponents workshop the required project (focus, implementation and deliverables)

- Theme and sub theme project proponents are required to participate at the challenge workshop. PISC agency Managers will identify the scientists to participate in the workshops
- Challenge workshops and project development must capture all the key researchers – this may include others who did not submit a proposal in the MLA call (eg Dairy Futures CRC, Uni Melbourne)
- Aim for cross regional projects where there are common outcomes (as described from the FIP consultation)
- Strategic science opportunities should be developed in the challenge workshops, then mapping of strategic science verses applied science is required in project areas to ensure appropriateness of investment to address a solution (eg in plant physiology and defoliation and persistence; soil biology and pasture health)
- Priority PISC agency priorities must be considered in the selection and project development process
- Market failure must be clearly defined as well as recognising public verses private benefit, prior to commitment of agency resources

Draft project areas and development issues have been identified and are to be addressed in the subsequent development process described in the Feedbase plan.

Inputs to the Pillars:
Plant breeding & evaluation

- Evaluation trials is an adoption project not a research program
- Niche verse traditional v opportunity in plan breeding needs determination. A decision tree is required which balances these areas and required investment
- Farming systems application is required in decisions about priority species, not just volume of the species
- Information presented to date does not assist determining the priority species for breeding

Productive & Sustainable pastures

- Nutrient balance is more appropriate than a focus on P
- Off site impacts should be explored in program areas
- Technologies to reduce cost of pasture establishment is an opportunity area
- Addressing pasture issues may be resolved by addressing animal & grazing approaches- eg by changing markets, enterprise mix. Overt links are required with the Grazing Systems pillar

Grazing management & Systems

- Integration of the feedbase components is a priority for this pillar
- Cost effective management of on farm and purchased feed types is stuffs is required – optimisation of the system (stubble, conserved, crops, pastures, purchased grain, hay)
- Use current management tools (eg fodder consideration, containment feeding more routinely to manage variable seasons and markets)
- Zonal management, precision tools, need exploration

Extension in the feedbase

- Target leading producers
- Research community needs development
- Other organisations who utilise the feedbasse research output
- Relevance to ‘my farm’ needs to be ensured in delivery actions
- The opportunity should be explored to use leading producer’s farms as case studies/ sites for delivery of system interactions
- In development utilise the extension skills and experiences form the dairy and grains industry

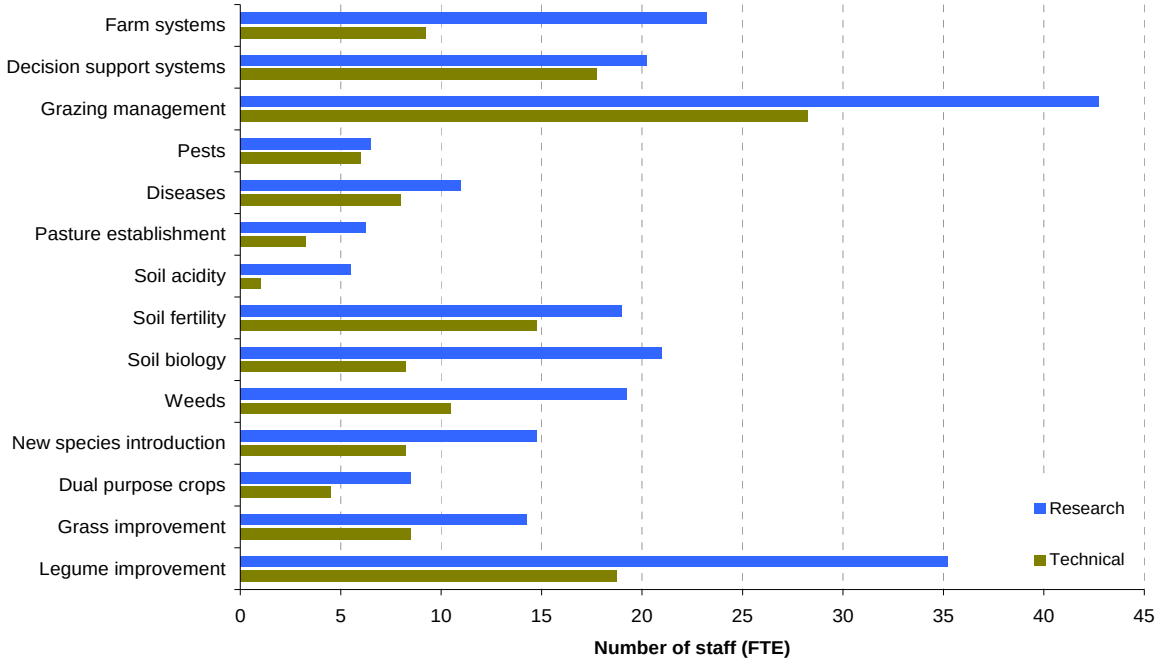
- Extension mist be flexible, start on a path that unfolds- developing skills, knowledge and confidence

Development of the plan

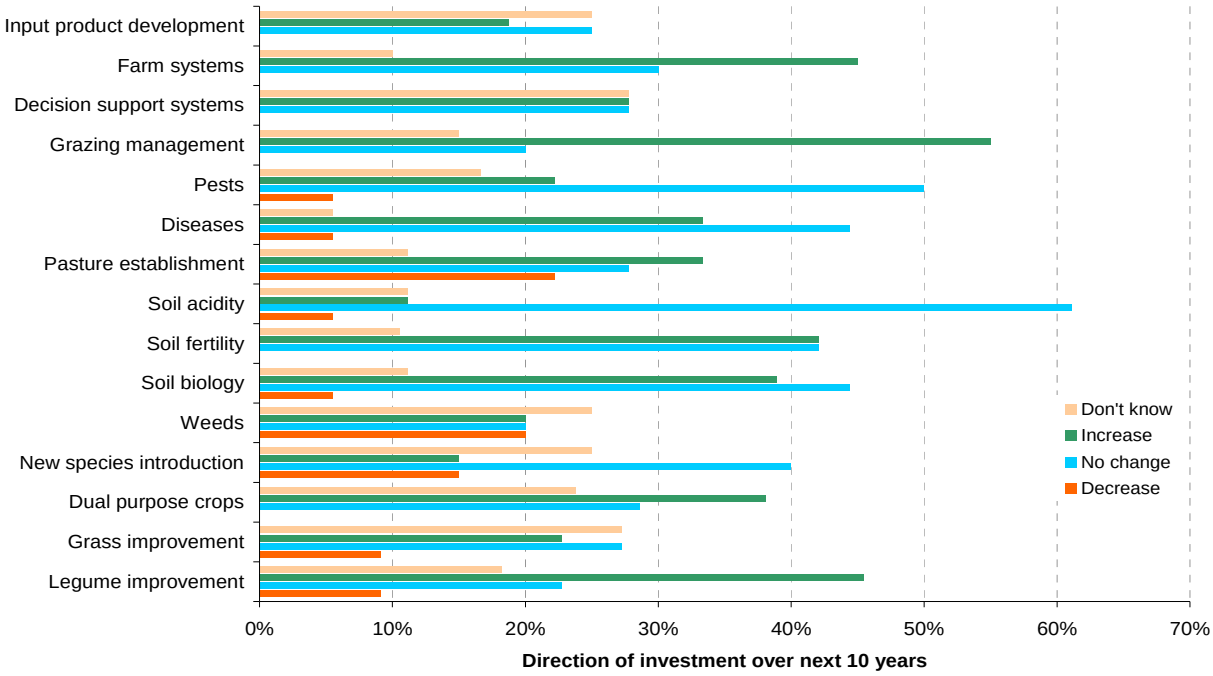
- Progress workshops with project proponents in like areas to shape a program
- Progress reviews of zonal management and precision technologies
- Seek cross- agro ecological zone activities where possible
- Agencies will nominate key representatives in discipline areas to shape a program. Recognition of ownership of the project IP is not to be lost

PISC Agency priorities and capacity (developed from consultation 2010)

1) Number (full time equivalent) of research and technical or support staff engaged in feedbase component research



2) Direction of research investment over the next ten years (start year 2010) for various feedbase components

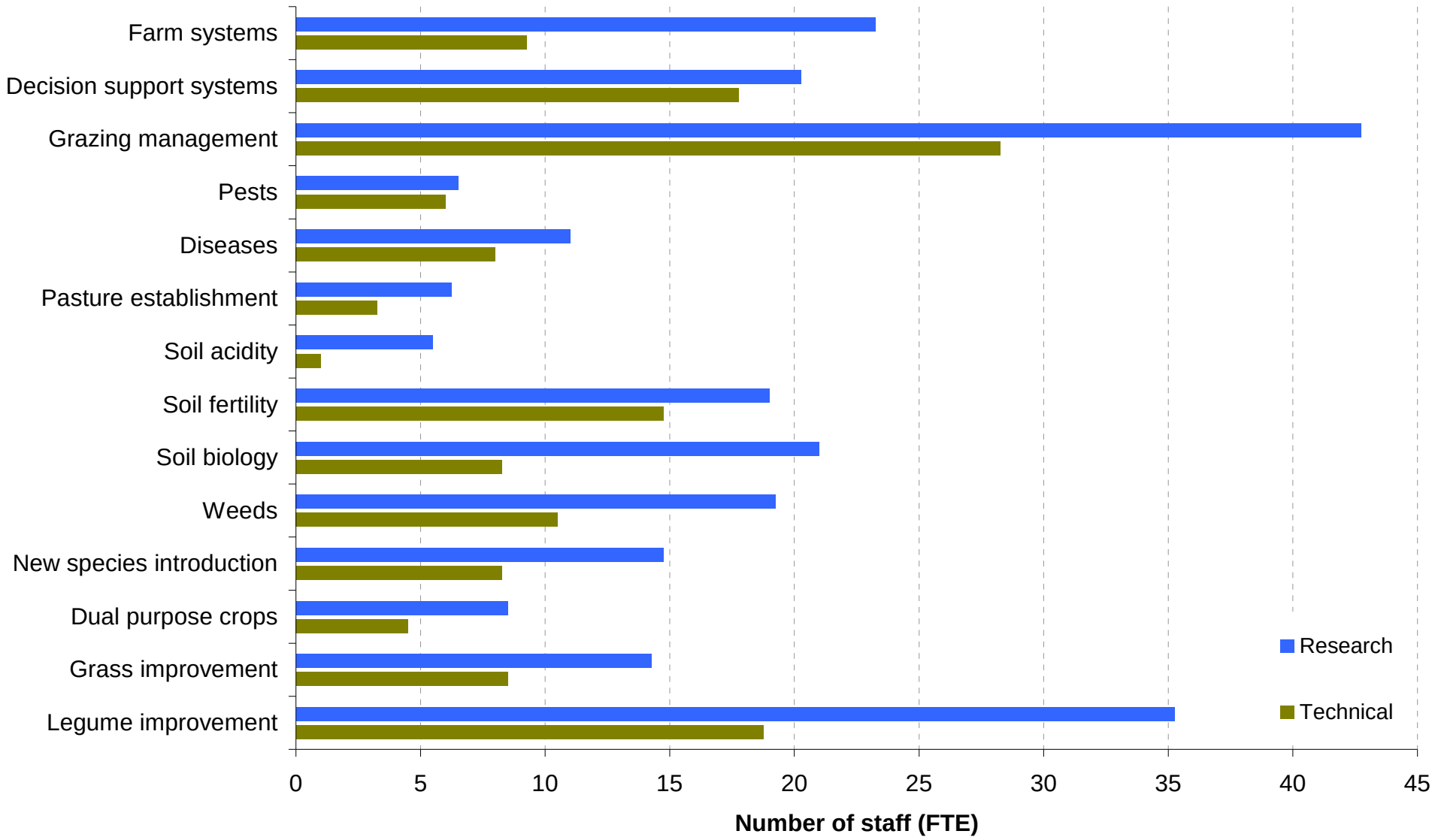

Input product development
Farm systems
Decision support systems
Grazing management
Pests
Diseases
Pasture establishment
Soil acidity
Soil fertility
Soil biology
Weeds
New species introduction
Dual purpose crops
Grass improvement
Legume improvement
Don't know
Increase
No change
Decrease
0%
10%
20%
30%
40%
50%
60%
70%
Direction of investment over next 10 years

Summation of staff numbers across the components provides 248 full-time equivalent research and 147 technical and support staff.

Organisations (number[A]) with research expertise located within research organisations with relevance to agro-ecological region.

Feedbase component	Arid interior	Temperate slopes and plains	Temperate highlands	Wet temperate coast	Subtropical slopes and plains	Semi-arid tropical plains
Legume improvement	0	9	10	7	2	1
Grass improvement	1	7	9	6	2	1
Dual purpose crops	0	7	6	4	2	1
New species introduction	1	9	8	4	2	1
Weeds	5	10	8	5	5	6
Soil biology	1	7	6	3	4	2
Soil fertility	1	9	8	3	4	3
Soil acidity	1	8	5	3	2	1
Pasture establishment	1	6	8	3	3	2
Diseases	0	5	4	2	3	2
Pests	1	6	6	2	3	2
Grazing management	5	9	10	7	4	2
Decision support systems	2	4	4	3	3	3
Farm systems	3	8	6	4	5	4
Retail product development	0	0	2	0	1	1

[A]The sum of people within rows may over estimate the total number of people with the relevant expertise in each component because expertise may be relevant to multiple regions.


Farm systems
Decision support systems
Grazing management
Pests
Diseases
Pasture establishment
Soil acidity
Soil fertility
Soil biology
Weeds
New species introduction
Dual purpose crops
Grass improvement
Legume improvement
0
5
10
15
20
25
30
35
40
45
Number of staff (FTE)
Research
Technical

APPENDIX J

Meat & Livestock Australia Strategic requirements

The following information reflects the strategic and tactical priorities of MLA described in the MLA Strategic plan to 2015.

The feedbase and its management directly contributes to the productivity, profitability and sustainability of the southern livestock industries. In a developing portfolio, both production and environmental outcomes are to be delivered.

Targeted Strategies

- Enhance rates of genetic improvement in flock, herd and feedbase performance
- Increase feed productivity and sustainability
- Optimise utilisation rates and productivity in grazing and feeding systems
- Increase labour efficiencies through new technology
- Develop and promote information and tools that help natural resource management and productivity
- Support industry participants to assess natural resource impacts and demonstrate environmental stewardship

Assumptions

The above outcomes assume that the following approaches will be implemented in the portfolio:

- Information meets the needs of the producers, producer will be involved in planning and review of research projects
- Producers will be interacting with scientist at all stages of development and implementation
- Benefits proposed from the research will need to be substantiated by market assessment, rather than opportunistic claims
- Due to researcher fragmentation, and limited capacity in feedbase research, improved output can be achieved by collective development of programs across organisations
- Strategic science investigations should be utilised to explore options towards an industry application to improve the focus of applied research. This will require a longer term planning period
- Pre-experimental modelling is used to provide stretch in project goal. The research should be beyond the confidence limits of the models and so focuses on topics where a significant benefit could be realised
- Opportunities from exploring improvements in the feedbase do not have to come to fruition, if the project review process identifies limited commercialisation opportunities
- Where possible, multiple outcomes in production and nrm are to be realised from a single intervention. This by implication requires multi- disciplinary research teams
- To assist producer determination of whether a technology is suitable for their individual system and circumstance, a triple bottom line assessment of a technology is required prior to delivery. Tradeoffs, synergies, antagonisms across the triple bottom line will assist individual producers assess the fit into their business, based on their particular motivations, aspirations and capability.
- Resource use efficiency (human, financial and physical) is paramount to managing a successful livestock business. Implications on resource use efficiency are required from any technology

- Producers associated with research projects can provide qualitative input into the technologies and application on farm
- Feedbase and animal production research should utilise the current best management practices in these areas, supporting a delivery message of “Best genetics (plants and animals), Best feeding, Best management”

Outcomes

- Objective data on genetic trends in production (income and cost) traits in beef cattle, sheep and pastures
- New tools and technologies demonstrated to improve business performance through productivity and/or product quality at the enterprise level
- Adoption of best management practices known to reduce environmental impacts in the production.

APPENDIX K

Feedbase Investment Program (FIP) Benefit Cost Analysis

- Plant Breeding and Evaluation
- Productive and Sustainable Pastures
- Grazing Management, Productive Systems

Prepared for:

Draft Report

1 September 2011

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DISCLAIMER

All description, figures, analyses, forecasts and other details have been prepared in good faith from information furnished to Michael Clarke of AgEconPlus Pty Ltd by other parties. These data are believed to be correct at the date of preparation of this report.

However, it should be noted that predictions, forecasts and calculations are subject to assumptions which may or may not turn out to be correct and AgEconPlus Pty Ltd expressly disclaim all and any liability to any persons in reliance, in whole or in part, on the report in total or any part of its contents.

Michael Clarke
AgEconPlus Pty Ltd

Executive Summary

Benefit cost analyses were prepared to identify high priority/high impact MLA investments within three proposed Feedbase Investment Plan 2012 to 2017 programs:

- Pasture breeding and evaluation
- Productive and sustainable pastures
- Grazing management and productive systems

The three programs are made up of ten themes and analysis was completed at the theme level. A total annual MLA investment of $4.6 million is proposed.

Investment returns are driven by the number of 'Top 20' livestock producers who adopt research outputs and the number of livestock/area of production they control. Data to estimate these key variables was developed in a Feedbase Project Review Workshop 30 – 31 March 2011. Nevertheless, a degree of uncertainty exists around these data and this is tested through the sensitivity analysis.

Table E.1 summarises results for core assumptions along with a pessimistic outlook for research adoption. Only Net Present Value (NPV) results are provided in the summary table. The body of this document includes estimates of other investment criteria.

Table E.1 Evaluation Results (NPV, 30 Year Analysis Period, discount rate 7%)

Theme	Pessimistic Scenario	Core Scenario
1. Pasture Breeding and Evaluation		
1.1 Species and variety evaluation	5.6	13.1
1.2 Species with existing public or private breeding programs	13.0	27.1
1.3 New Traits and breeding technologies	11.8	26.0
1.4 Novel species	1.0	2.8
2. Productive and Sustainable Pastures		
2.1 Productive soils	6.8	16.9
2.2 Pasture and agronomy management	2.5	8.5
2.3 Pasture health	2.6	6.0
3. Grazing Management and Productive Systems		
3.1 Pasture and livestock indicators	6.2	14.4
3.2 Livestock system design	9.7	20.2
3.3 Integration of feeds into productive systems	6.3	14.2
Total	**65.5**	**149.2**

Best available data ('core scenario') would indicate a total NPV of $149.2 million over 30 years and a balanced portfolio of investments with acceptable positive NPVs across all themes. The parametric analysis shows that for the 'pessimistic scenario' all themes continue to generate a positive NPV.

1 Introduction

1.1 Analysis Purpose

This document is a benefit cost analysis (BCA) of components of the proposed Meat and Livestock Australia (MLA) Feedbase Investment Plan (FIP) 2012 to 2017. Benefit cost analyses were completed by AgEconPlus with support from MLA staff in April and August 2011.

Benefit cost analyses were prepared to identify high priority/high impact MLA investments within three of six proposed Feedbase Programs:

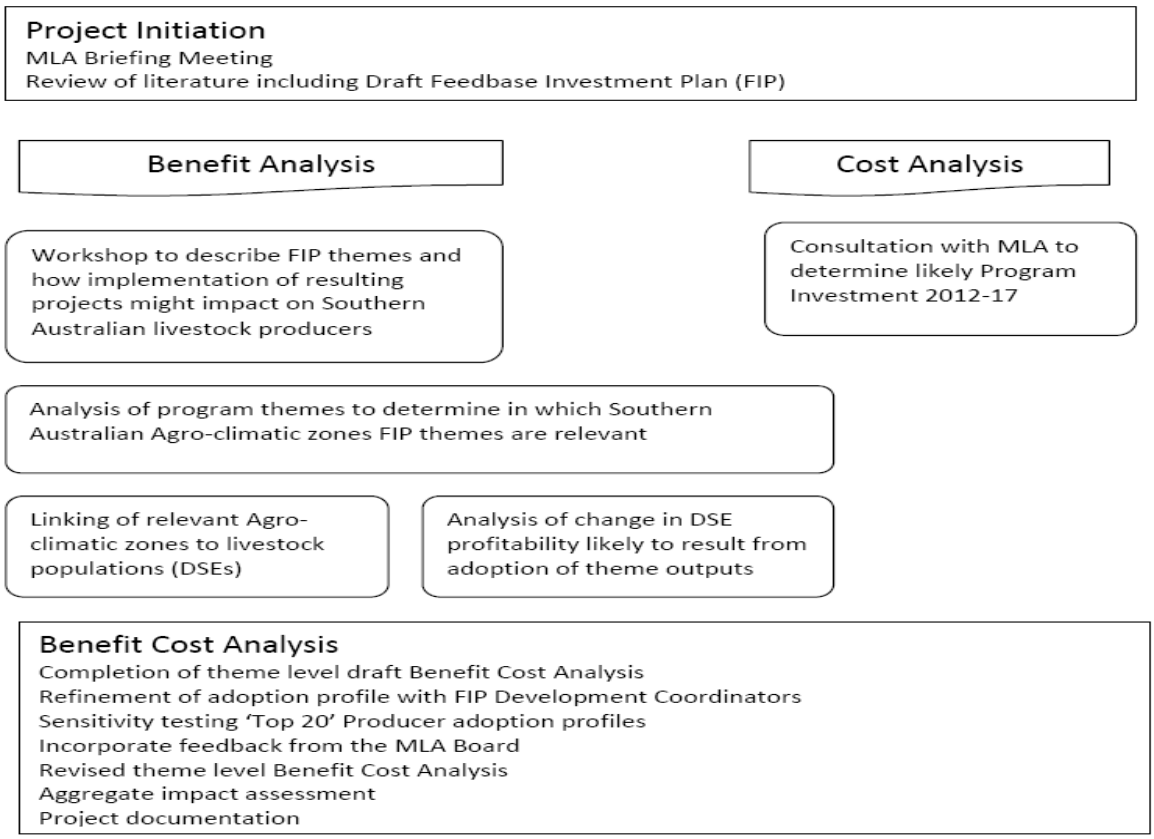
- Plant breeding and evaluation
- Productive and Sustainable pastures
- Grazing management and production systems

Other programs not analysed in this document include themes associated with 'weeds', 'decision support tools' and 'soils'.

1.2 Study Approach

Analyses were completed after consideration of background reports including the Feedbase Investment Plan, using advice received from the Feedbase Project Review Workshop of 30 - 31 March 2011, application of MLA's Rapid Evaluation Ranking (RER) process and standard benefit cost analysis techniques (as outlined in the Council of Rural Research and Development Corporations (CRRDC) R&D Evaluation Guidelines, revised 2009).

A schematic outlining the approach taken is outlined below.



Costs considered in the evaluation included:

- MLA investment costs – developed at the Feedbase Project Review Workshop and estimated for the five years 2012 to 2017.
- Co-investment costs eg those incurred by research organisations to deliver FIP projects including 'in-kind' investments. These costs were addressed through estimating the attribution of benefits to each project (see below).
- Implementation costs eg capital costs incurred by red meat producers to implement research outputs. These costs were also addressed through attribution of gross project benefits.

Benefits considered in the evaluation included:

- Change in enterprise profitability – percentage change in enterprise profitability agreed at the Feedbase Project Review Workshop and quantified using Holmes Sackett data for beef and dual purpose sheep enterprises in Southern Australia (Holmes Sackett 2010).
- Livestock numbers for which benefits are applicable – determined using FIP analysis of livestock numbers in Southern Australia by agro-climatic region.
- Adoption rate – focussing in the first instance on the Top 20% of producers in Southern Australia with allowance for additional adoption amongst the balance of red meat enterprises.
- Probability of research success – determined against historical investments by MLA and others in the pasture improvement RD&E 'space'.
- Attribution of benefits to MLA investment – gross benefit assessment numbers were adjusted downward for other factors contributing to the research outcome (eg knowledge gleaned from other sources) and the cost of benefit realisation (eg capital investment required by red meat producers who adopt the innovation).

Benefit cost reporting addressed:

- The Present Value of Benefits (PVB) and Present Value of Costs (PVC) were used to estimate investment criteria of Net Present Value (NPV) and Benefit-Cost Ratio (BCR) at discount rate of 7% real. The PVB and PVC are the sums of the discounted streams of benefits and costs. The discounting is used to allow for the time value of money, and the discount rate of 7% is that specified by MLA. The Internal Rate of Return (IRR) was also calculated.
- An analysis period of 30 years starting after the last year of investment was used to estimate theme benefits.
- The benefit cost analyses considered the triple bottom line. Environmental and social benefits and costs were presented as a qualitative assessment using information gleaned from the Feedbase Project Review Workshop.
- Sensitivity analyses were undertaken in most cases for those variables where there was greatest uncertainty or for those that were thought to be key drivers of the investment criteria.

1.3 FIP Themes Evaluated

Analyses were completed at the FIP 'theme' level and ten themes were developed at the Feedbase Project Review Workshop and refined with MLA, they were:

Plant breeding and evaluation

- Species and variety evaluation
- Species with existing public or private breeding programs
- New traits and breeding technologies
- Novel species

Productive and sustainable pastures

- Productive soils
- Pasture agronomy and management
- Pasture health

Grazing management and productive systems

- Pasture and livestock indicators
- Livestock systems design
- Integration of additional feeds

To drive the evaluation overarching data was agreed at the Feedbase Project Review Workshop and subsequently with MLA.

2 Overarching Data to Drive the Analysis

2.1 Proposed Investment in FIP Themes

The Feedbase Investment Plan is relevant to Southern Australia. Historically MLA has invested around $4 million per annum in pasture and related research, development and extension. Possible future feedbase investment might be allocated across the three programs considered in this evaluation on the following basis.

Table 2.1 Indicative MLA Investment in Southern Australian Feedbase 2012-2017 ($ pa)

Pillar and Theme	Preferred Annual Investment
1. Pasture Breeding and Evaluation	
1.1 Species and variety evaluation	500,000
1.2 Species with existing public or private breeding programs	250,000
1.3 New traits and breeding technologies	600,000
1.4 Novel species	200,000
Total	**1,550,000**
2. Productive and Sustainable Pastures	
2.1 Productive soils	850,000
2.2 Pasture agronomy and management	900,000
2.3 Pasture health	200,000
Total	**1,950,000**
3. Grazing Management and Production Systems	
3.1 Pasture and livestock indicators	500,000
3.2 Livestock systems design	200,000
3.3 Integration of feeds into productive systems	400,000
Total	**1,100,000**

Source: Feedbase R&D Plan Approved Draft May 2011

Allocations within programs were developed at the Feedbase Project Review Workshop and refined in the Feedbase R&D Plan (May 2011).

2.2 Southern Australia Livestock Numbers

Southern Australian livestock numbers by agro-climatic zone were sourced from the FIP and are reported in the table below.

Table 2.2 Livestock in Southern Australia by Agro-climatic Zone (million DSE)[1]

	Total	Temperate highlands	Temperate slopes and plains	Arid interior	Semi Arid Sub-tropical	Wet Temp Coast	Sub tropical slopes plains
Sheep - %	100%	15%	56%	8%	3%	15%	3%
Cattle - %	100%	29%	35%	5%	3%	24%	5%
Sheep – million head	72.7	11.2	41.0	5.5	1.9	11.2	1.9
Cattle – million head	9.8	2.8	3.4	0.5	0.3	2.3	0.5
Sheep – million DSE	72.7	11.2	41.0	5.5	1.9	11.2	1.9
Cattle – million DSE	107.8	30.8	37.4	5.5	3.3	25.3	5.5
Total DSE	**180.50**	**42.00**	**78.40**	**11.00**	**5.20**	**36.50**	**7.40**

Source: FIP and AgEconPlus analysis

Investment in the FIP has potential to affect profitability on red meat producing properties stocking more than 180 million DSE.

[1] Flock sheep and cattle numbers were converted to DSE assuming one flock sheep was equivalent to one DSE and one head of cattle was equivalent to eleven DSE.

2.3 Linking Themes to Climatic Zones and Livestock Numbers

FIP 'theme' relevance by agro-climatic zone and livestock with potential to benefit from FIP delivery are shown in Tables 2.3 and 2.4.

Table 2.3 Relevance of FIP Theme to Southern Australia Agro-climatic Zones

Program and Theme	Temperate highlands	Temperate slopes and plains	Arid interior	Semi Arid Subtropical	Wet Temperate Coast	Sub tropical slopes plains
1. Pasture Breeding and Evaluation						
1.1 Species and variety evaluation	√√√	√√√		√	√√√	√√
1.2 Species with existing public or private breeding programs	√√√	√√√			√√√	
1.3 New traits and breeding technologies	√√√	√√√			√√√	
1.4 Novel species	√√	√√		√	√√	√
2. Productive and Sustainable Pastures						
2.1 Productive soils	√√√	√√√	√√√	√√√	√√√	√√√
2.2 Pasture and agronomy management	√√	√√√	√	√	√√√	√√
2.3 Pasture health	√√	√√√	√	√	√√√	√√
3. Grazing Management and Productive Systems						
3.1 Pasture and livestock indicators	√√√	√√√	√√	√√	√√√	√√√
3.2 Livestock system design	√√√	√√√	√	√	√√√	√√√
3.3 Integration of feeds into productive systems	√	√√√	√√	√√	√	√√
Total	**25**	**29**	**10**	**12**	**27**	**18**

Source: FIP DCs April 2011

FIP themes evaluated in this economic analysis are relevant to all Southern Australia agro-climatic zones. Red meat producers in the Temperate Slopes and Plains, Wet Temperate Coast and Temperate Highlands have the highest number of themes that are relevant to their enterprises.

Application of theme relevance data (Table 2.3) to livestock population information (Table 2.2) allows estimation of livestock with potential to benefit from FIP delivery (Table 2.4).

Table 2.4 Livestock with POTENTIAL to Benefit from FIP Theme Delivery (million DSE)

Program and Theme	TOTAL DSE	Temperate highlands	Temperate slopes and plains	Arid interior	Semi Arid Subtropical	Wet Temperate Coast	Sub tropical slopes plains
1. Pasture Breeding and Evaluation							
1.1 Species and variety evaluation	163.27	42.00	78.40	-	1.56	36.50	4.81
1.2 Species with existing public or private breeding programs	156.90	42.00	78.40	-	-	36.50	-
1.3 New traits and breeding technologies	156.90	42.00	78.40	-	-	36.50	-
1.4 Novel species	105.77	27.30	50.96	-	1.56	23.73	2.22
2. Productive and Sustainable Pastures	-	-	-	-	-	-	-
2.1 Productive soils	180.50	42.00	78.40	11.00	5.20	36.50	7.40
2.2 Pasture and agronomy management	151.87	27.30	78.40	3.30	1.56	36.50	4.81
2.3 Pasture health	151.87	27.30	78.40	3.30	1.56	36.50	4.81
3. Grazing management and productive systems	-	-	-	-	-	-	-
3.1 Pasture and livestock indicators	174.83	42.00	78.40	7.15	3.38	36.50	7.40
3.2 Livestock system design	169.16	42.00	78.40	3.30	1.56	36.50	7.40
3.3 Integration of feeds into productive systems	117.29	12.60	78.40	7.15	3.38	10.95	4.81

Source: AgEconPlus analysis – livestock numbers by theme relevance where √√√ = 100% of livestock population, √√=65% and √=30%

Each theme has POTENTIAL relevance to a substantial Southern Australian livestock population. This potential livestock pool is discounted prior to benefit estimation. An explanation of the reasons for 'discounting' is provided below.

2.4 Additional Enterprise Profit from Theme Adoption

Successful delivery of FIP themes will generate additional enterprise profitability for both 'Top 20%' producers and a proportion of those producers who are outside the 'Top 20%'.

Current red meat producer profitability data was sourced from the Southern Beef Situation Analysis prepared for MLA by Holmes Sackett (2010) for both beef and dual purpose sheep enterprises and is reported in the table below.

Table 2.5 Current Southern Australian Livestock Profitability – Beef and Dual Purpose Sheep

	Beef	Dual Purpose Sheep	Average Across Enterprises
Rainfall (mm)	600	600	600
Average annual DSE/ha	11.76	11.78	11.77
11 year average net profit ($/DSE)	3.83	5.09	4.46

Source Holmes Sackett 2010

Base level profitability prior to implementation of FIP themes is estimated to have averaged $4.46/DSE over the eleven years to 2010.

Representative Top 20% red meat producers were asked at the Feedbase Project Review Workshop to estimate the impact theme delivery would have on current red meat enterprise profitability along with the time it would take for the research to be adopted by Top 20% producers after it became commercially available. Results are summarised in Table 2.6.

Table 2.6 Additional Enterprise Profit Associated with Theme Delivery

	Impact on Enterprise Profit (% increase)	Time required to Get Top 20% of Producers to Adopt (years)
1. Pasture Breeding and Evaluation		
1.1 Species and variety evaluation	<15%	5 years
1.2 Species with existing public or private breeding programs	<15%	5 years
1.3 New traits and breeding technologies	>15%	5 years
1.4 Novel species	>15%	10 years
2. Productive and Sustainable Pastures		
2.1 Productive soils	>15%	10 years
2.2 Pasture and agronomy management	<15%	15 years
2.3 Pasture health	<15%	15 years
3. Grazing Management and Productive Systems		
3.1 Pasture and livestock indicators	>15%	8 years
3.2 Livestock system design	>15%	5 years
3.3 Interactions of feeds into productive systems	<15%	4 years

Source: Feedbase Project Review Workshop March 2011 and advice received from MLA

It is noted that a 15% improvement in profitability is likely to be conservative – leading producers who provided these estimates have already discounted the cost of implementation and theme success.

2.5 Theme Adoption Rates and Timing

The Feedbase Project Review Workshop raised but did not resolve the issue of defining the Top 20% of Southern Australia red meat producers. In a subsequent meeting with the DCs it was agreed that while the Top 20% of producers might not control 80% of Southern Australia red meat DSEs they certainly controlled more than 20% of production. Furthermore it was agreed that a proportion of producers outside the Top 20% would also adopt outcomes of FIP theme investments within this evaluation's 30 year analysis period – see Table 2.7 below.

Table 2.7 Maximum DSEs that Will Adopt Theme Outcomes (million DSE)

	Total DSEs with Potential to Benefit from Theme Success (Table 2.4)	% of DSEs Managed by Top 20 Producers	% of DSEs with Other Producers who Adopt	Maximum DSE that adopt theme outcomes
1. Pasture Breeding and Evaluation				
1.1 Species and variety evaluation	163.27	40%	10%	**81.64**
1.2 Species with existing public or private breeding programs	156.90	40%	10%	**78.45**
1.3 New traits and breeding technologies	156.90	40%	10%	**78.45**
1.4 Novel species	105.77	40%	10%	**52.89**
2. Productive and Sustainable Pastures				
2.1 Productive soils	180.50	40%	10%	**90.25**
2.2 Pasture and agronomy management	151.87	40%	10%	**75.94**
2.3 Pasture health	151.87	40%	10%	**75.94**
3. Grazing Management and Productive Systems				
3.1 Pasture and livestock indicators	174.83	40%	10%	**87.42**
3.2 Livestock system design	169.16	40%	10%	**84.58**
3.3 Integration of feeds into productive systems	117.29	40%	10%	**58.64**

Source: AgEconPlus assumption following discussion with Feedbase Investment Plan DCs

Timing of outcome adoption will be theme specific and is described in chapter 3.

The above data informs FIP benefit cost analyses.

3. Benefit Cost Analysis by FIP Theme

3.1 Species and Variety Evaluation

Theme Description and Outcome Statement

This theme addresses the evaluation of pasture species. When delivered Australian meat producers will be able to increase productivity and profitability by 10% through making informed choices on pasture technologies based on robust and accurate description of these technologies against key drivers of profitability and productivity.

Theme Investment

An MLA investment of $500,000 pa for five years is proposed (see Table 2.1).

Benefit Estimation

Delivery of this theme will improve red meat enterprise profitability. Key assumptions used to quantify this impact are summarised in the table below.

Variable	Assumption	Source
Maximum DSE that will adopt theme outcome (million)	81.64 million DSE	Chapter 2 analysis – Table 2.7
Current red meat enterprise profitability ($/DSE)	$4.46/DSE	Holmes Sackett 2010
Increase in profit attributable to theme success	10%	Chapter 2 analysis – Table 2.6
Probability of this outcome being achieved	50%	Consultant estimate based on historical investments in the pasture improvement RD&E 'space'.
Attribution of the improvement to MLA's investment	25%	Consultant estimate after consideration of other RD&E investments and capital cost of new pasture establishment.
Likely time from completion of research investment to market ready state	0 years	MLA advice.
Number of years from market ready state until maximum adoption achieved	3 years	Chapter 2 analysis – Table 2.6
Likely time from market ready state until theme outcome is superseded / obsolescent	30 years	MLA advice.

Potentially delivery of this theme will result in improved groundcover and reduced soil loss with subsequent off-farm environmental improvements (eg reduced wind and water born sediment). There are no social benefits envisaged from investment in this cluster.

3.2 Species with Existing Public or Private Breeding Programs

Theme Description and Outcome Statement

This theme addresses pasture species with existing breeding programs. When delivered Australian meat producers will be able to increase productivity and profitability by 15% through the more rapid breeding of cultivars and the incorporation of novel traits and attributes into these cultivars.

Theme Investment

An MLA investment of $250,000 pa for five years is proposed (see Table 2.1).

Benefit Estimation

Delivery of this theme will improve red meat enterprise profitability. Key assumptions used to quantify this impact are summarised in the table below.

Variable	Assumption	Source
Maximum DSE that will adopt theme outcome (million)	78.45 million DSE	Chapter 2 analysis – Table 2.7
Current red meat enterprise profitability ($/DSE)	$4.46/DSE	Holmes Sackett 2010
Increase in profit attributable to theme success	15%	Chapter 2 analysis – Table 2.6
Probability of this outcome being achieved	50%	Consultant estimate based on historical success of pasture breeding program.
Attribution of the improvement to MLA's investment	25%	Consultant estimate after consideration of other RD&E investments and capital cost of new pasture establishment.
Likely time from completion of research investment to market ready state	2 years	MLA advice.
Number of years from market ready state until maximum adoption achieved	5 years	Chapter 2 analysis – Table 2.6
Likely time from market ready state until theme outcome is superseded / obsolescent	10 years	MLA advice.

Minor groundcover related environmental improvements possible. There are no social benefits envisaged from investment in this cluster.

3.3 New Traits and Breeding Technologies

Theme Description and Outcome Statement

This theme addresses the development of traits and tools to greatly enhance the rate of genetic gain in forage species. When delivered Australian meat producers will be able to increase productivity and profitability by greater than 15% through the incorporation of greatly improved cultivars into their feedbase.

Theme Investment

An MLA investment of $600,000 pa for five years is proposed (see Table 2.1).

Benefit Estimation

Delivery of this theme will improve red meat enterprise profitability. Key assumptions used to quantify this impact are summarised in the table below.

Variable	Assumption	Source
Maximum DSE that will adopt theme outcome (million)	78.45 million DSE	Chapter 2 analysis – Table 2.7
Current red meat enterprise profitability ($/DSE)	$4.46/DSE	Holmes Sackett 2010
Increase in profit attributable to theme success	20%	Chapter 2 analysis – Table 2.6
Probability of this outcome being achieved	75%	Consultant estimate based on 'traits' being a new and therefore highly prospective area of research.
Attribution of the improvement to MLA's investment	25%	Consultant estimate after consideration of other RD&E investments and capital cost of new pasture establishment.
Likely time from completion of research investment to market ready state	10 years	MLA advice.
Number of years from market ready state until maximum adoption achieved	5 years	Chapter 2 analysis – Table 2.6
Likely time from market ready state until theme outcome is superseded / obsolescent	10 years	MLA advice.

No environmental or social benefits identified from investment in this cluster.

3.4 Novel Species

Theme Description and Outcome Statement

This theme addresses the identification and breeding of new and novel pasture species. When delivered Australian meat producers will be able to increase productivity and profitability by greater than 15% in certain parts of their business through the incorporation of novel species into their feedbase.

Theme Investment

An MLA investment of $200,000 pa for five years is proposed (see Table 2.1).

Benefit Estimation

Delivery of this theme will improve red meat enterprise profitability. Key assumptions used to quantify this impact are summarised in the table below.

Variable	Assumption	Source
Maximum DSE that will adopt theme outcome (million)	52.89 million DSE	Chapter 2 analysis – Table 2.7
Current red meat enterprise profitability ($/DSE)	$4.46/DSE	Holmes Sackett 2010
Increase in profit attributable to theme success	20%	Chapter 2 analysis – Table 2.6
Probability of this outcome being achieved	30%	Consultant estimate based on low probability of finding new species.
Attribution of the improvement to MLA's investment	25%	Consultant estimate after consideration of other RD&E investments and capital cost of new pasture establishment.
Likely time from completion of research investment to market ready state	15 years	MLA advice.
Number of years from market ready state until maximum adoption achieved	10 years	Chapter 2 analysis – Table 2.6
Likely time from market ready state until theme outcome is superseded / obsolescent	20 years	MLA advice.

No environmental or social benefits identified from investment in this cluster.

3.5 Productive Soils

This theme is focused on identifying the factors which limit the supply and use of key soil nutrients such as nitrogen and phosphorus, and providing resolutions which will allow the more effective, efficient and economic use of these nutrients for pasture production.

Theme Investment

An MLA investment of $850,000 pa for five years is proposed (see Table 2.1).

Benefit Estimation

Delivery of this theme will improve red meat enterprise profitability. Key assumptions used to quantify this impact are summarised in the table below.

Variable	Assumption	Source
Maximum DSE that will adopt theme outcome (million)	90.25 million DSE	Chapter 2 analysis – Table 2.7
Current red meat enterprise profitability ($/DSE)	$4.46/DSE	Holmes Sackett 2010
Increase in profit attributable to theme success	20%	Chapter 2 analysis – Table 2.6
Probability of this outcome being achieved	50%	Consultant estimate based on outcome statement.
Attribution of the improvement to MLA's investment	10%	Consultant estimate after consideration of other RD&E investments.
Likely time from completion of research investment to market ready state	2 years	MLA advice.
Number of years from market ready state until maximum adoption achieved	10 years	Chapter 2 analysis – Table 2.6
Likely time from market ready state until theme outcome is superseded / obsolescent	20 years	MLA advice.

Potentially delivery of this theme will result in more effective application of nutrients at lower rates with reduced risk off-farm environmental pollution (eg water born sediment). There are no social benefits envisaged from investment in this cluster.

3.6 Pasture and Agronomy Management

Theme Description and Outcome Statement

This theme addresses increased pasture yield, improved persistence, consistent legume performance and companion species.

Theme Investment

An MLA investment of $900,000 pa for five years is proposed (see Table 2.1).

Benefit Estimation

Delivery of this theme will improve red meat enterprise profitability. Key assumptions used to quantify this impact are summarised in the table below.

Variable	Assumption	Source
Maximum DSE that will adopt theme outcome (million)	75.94 million DSE	Chapter 2 analysis – Table 2.7
Current red meat enterprise profitability ($/DSE)	$4.46/DSE	Holmes Sackett 2010
Increase in profit attributable to theme success	10%	Chapter 2 analysis – Table 2.6
Probability of this outcome being achieved	50%	Consultant estimate based on historical investments in the pasture improvement RD&E 'space'.
Attribution of the improvement to MLA's investment	25%	Consultant estimate after consideration of other RD&E investments and capital cost of new pasture establishment.
Likely time from completion of research investment to market ready state	5 years	MLA advice.
Number of years from market ready state until maximum adoption achieved	15 years	Chapter 2 analysis – Table 2.6
Likely time from market ready state until theme outcome is superseded / obsolescent	25 years	MLA advice.

Potentially delivery of this theme will result in improved groundcover and reduced soil loss with subsequent off-farm environmental improvements (eg reduced wind and water born sediment). There are no social benefits envisaged from investment in this cluster.

3.7 Pasture Health

Theme Description and Outcome Statement

This theme focuses on specific issue management (i.e. insect control and rhizobia) and tools which will assist livestock producers in their "zonal management" of soils and pastures – the outcome of which will lead to more efficient, effective and sustainable use of resources (i.e. pasture, soil, water, manpower, fertiliser etc).

Theme Investment

An MLA investment of $200,000 pa for five years is proposed (see Table 2.1).

Benefit Estimation

Delivery of this theme will improve red meat enterprise profitability. Key assumptions used to quantify this impact are summarised in the table below.

Variable	Assumption	Source
Maximum DSE that will adopt theme outcome (million)	75.94 million DSE	Chapter 2 analysis – Table 2.7
Current red meat enterprise profitability ($/DSE)	$4.46/DSE	Holmes Sackett 2010
Increase in profit attributable to theme success	10%	Chapter 2 analysis – Table 2.6
Probability of this outcome being achieved	50%	Consultant estimate based on historical investments in the pasture improvement RD&E 'space'.
Attribution of the improvement to MLA's investment	25%	Consultant estimate after consideration of other RD&E investments needed to realise forecast benefit.
Likely time from completion of research investment to market ready state	5 years	MLA advice.
Number of years from market ready state until maximum adoption achieved	15 years	Chapter 2 analysis – Table 2.6
Likely time from market ready state until theme outcome is superseded / obsolescent	15 years	MLA advice.

Potentially delivery of this theme will result in more efficient use of fertiliser and water resulting in improved environmental outcomes. There are no social benefits envisaged from investment in this cluster.

3.8 Pasture and Livestock Indicators

Theme Description and Outcome Statement

Remote digital collection of pasture and livestock performance to inform grazing and other management activities that optimise stocking rate, livestock and pasture performance and livestock health and welfare in consideration of target market specifications. Data collection needs to capture pasture and livestock performance in real time to inform decision support services in order to optimise the grazing system.

Theme Investment

An MLA investment of $500,000 pa for five years is proposed (see Table 2.1).

Benefit Estimation

Delivery of this theme will improve red meat enterprise profitability. Key assumptions used to quantify this impact are summarised in the table below.

Variable	Assumption	Source
Maximum DSE that will adopt theme outcome (million)	87.42 million DSE	Chapter 2 analysis – Table 2.7
Current red meat enterprise profitability ($/DSE)	$4.46/DSE	Holmes Sackett 2010
Increase in profit attributable to theme success	20%	Chapter 2 analysis – Table 2.6
Probability of this outcome being achieved	50%	Consultant estimate based on adaptation of technologies from other industries.
Attribution of the improvement to MLA's investment	10%	Consultant estimate after consideration of other RD&E investments and capital cost incurred to implement remote digital technology on farm.
Likely time from completion of research investment to market ready state	5 years	MLA advice.
Number of years from market ready state until maximum adoption achieved	8 years	Chapter 2 analysis – Table 2.6
Likely time from market ready state until theme outcome is superseded / obsolescent	40 years	MLA advice.

Technology developed may have application for NRM monitoring (environmental benefit) and community protection measures such as bushfire fuel warnings and improved animal welfare outcomes (social benefit).

3.9 Livestock System Design

This theme addresses the capture and interpretation of remote and local data to inform actions which optimise grazing and production systems in consideration of enterprise, market specification, risk exposure and complexity. Focus will be on strategic design decisions, flexible systems for variable seasons/markets and enterprise mix.

Theme Investment

An MLA investment of $200,000 pa for five years is proposed (see Table 2.1).

Benefit Estimation

Delivery of this theme will improve red meat enterprise profitability. Key assumptions used to quantify this impact are summarised in the table below.

Variable	Assumption	Source
Maximum DSE that will adopt theme outcome (million)	84.58 million DSE	Chapter 2 analysis – Table 2.7
Current red meat enterprise profitability ($/DSE)	$4.46/DSE	Holmes Sackett 2010
Increase in profit attributable to theme success	20%	Chapter 2 analysis – Table 2.6
Probability of this outcome being achieved	50%	Consultant estimate based on adaptation of technologies from other industries.
Attribution of the improvement to MLA's investment	10%	Consultant estimate after consideration of other RD&E investments and capital cost of system purchase.
Likely time from completion of research investment to market ready state	3 years	MLA advice.
Number of years from market ready state until maximum adoption achieved	5 years	Chapter 2 analysis – Table 2.6
Likely time from market ready state until theme outcome is superseded / obsolescent	30 years	MLA advice.

Technology developed may have application for NRM monitoring (environmental benefit) and community protection measures such as bushfire fuel warnings and improved animal welfare outcomes (social benefit).

3.10 Integration of Feeds into Productive Systems

Integration of additional feeds including crops, shrubs, niche pasture species, conserved fodder and containment feeding. Matching feed supply with animal and marketing needs will also be addressed.

Theme Investment

An MLA investment of $400,000 pa for five years is proposed (see Table 2.1).

Benefit Estimation

Delivery of this theme will improve red meat enterprise profitability. Key assumptions used to quantify this impact are summarised in the table below.

Variable	Assumption	Source
Maximum DSE that will adopt theme outcome (million)	58.64 million DSE	Chapter 2 analysis – Table 2.7
Current red meat enterprise profitability ($/DSE)	$4.46/DSE	Holmes Sackett 2010
Increase in profit attributable to theme success	10%	Chapter 2 analysis – Table 2.6
Probability of this outcome being achieved	50%	Consultant estimate based on outcome statement.
Attribution of the improvement to MLA's investment	25%	Consultant estimate after consideration of other RD&E investments and capital cost of pasture establishment.
Likely time from completion of research investment to market ready state	3 years	MLA advice.
Number of years from market ready state until maximum adoption achieved	4 years	Chapter 2 analysis – Table 2.6
Likely time from market ready state until theme outcome is superseded / obsolescent	20 years	MLA advice.

Theme addresses NRM targets (environmental benefits) and animal welfare (social benefits).

4. Summary and Conclusions

4.1 Core Assumptions

Table 4.1 Evaluation Results (30 year analysis period, discount rate 7%)

Theme	PV Benefits ($'million)	PV Costs ($'million)	NPV ($'million)	BCR	IRR (%)	Enviro	Social
1. Pasture Breeding and Evaluation							
1.1 Species and variety evaluation	15.0	1.9	13.1	7.8	36.0	√	Nil
1.2 Species with existing public or private breeding programs	28.1	1.0	27.1	28.75	48.2	√	Nil
1.3 New Traits and breeding technologies	28.3	2.3	26.0	12.31	24.8	Nil	Nil
1.4 Novel species	3.6	0.8	2.8	4.68	13.3	Nil	Nil
2. Productive and Sustainable Pastures							
2.1 Productive soils	20.1	3.3	16.9	6.18	20.9	√√	Nil
2.2 Pasture and agronomy management	11.9	3.4	8.5	3.45	13.8	√	Nil
2.3 Pasture health	6.8	0.8	6.0	8.9	22.7	√	Nil
3. Grazing Management and Productive Systems							
3.1 Pasture and livestock indicators	16.3	1.9	14.4	8.49	21.4	√√	√√
3.2 Livestock system design	21.0	0.8	20.2	27.4	38.5	√√	√√
3.3 Integration of feeds into productive systems	15.7	1.5	14.2	10.26	28.3	√√	√√
Total			**149.2**				

Key: √√√ Strong environmental or social outcomes, √√ moderate outcomes, √ minor outcomes.

Benefit cost analysis results across ten FIP themes show:

- A balanced portfolio of investments with acceptable positive NPVs across all themes.
- Highest returns are anticipated for investments in 'Species with Existing Public or Private Breeding Programs' and 'New Traits and Breeding Technologies'. In both instances high returns are driven by a large potential DSE benefit pool and rapid adoption.
- Nine of ten themes are anticipated to generate at least some environmental gain and three themes are expected to deliver social benefits.

4.2 Sensitivity Analysis: Top 20 Producers

The core assumptions for Maximum DSEs that will adopt theme outcomes shown in Table 2.7 have been halved for the following sensitivity analysis i.e. Top 20 Producers control only 20% of Total DSEs and Other Producers who adopt theme outcomes account for only 5% of relevant DSEs.

Table 4.2 Evaluation Results – Pessimistic Sensitivity Test (30 year analysis period, discount rate 7%)

Theme	PV Benefits ($'million)	PV Costs ($'million)	NPV ($'million)	BCR	IRR (%)	Enviro	Social
1. Pasture Breeding and Evaluation							
1.1 Species and variety evaluation	7.5	1.9	5.6	3.9	25.0	√	Nil
1.2 Species with existing public or private breeding programs	14.0	1.0	13.0	14.37	37.5	√	Nil
1.3 New Traits and breeding technologies	14.1	2.3	11.8	6.15	19.5.8	Nil	Nil
1.4 Novel species	1.8	0.8	1.0	2.34	10.4	Nil	Nil
2. Productive and Sustainable Pastures							
2.1 Productive soils	10.0	3.3	6.8	3.09	14.9	√√	Nil
2.2 Pasture and agronomy management	6.0	3.4	2.5	1.73	9.8	√	Nil
2.3 Pasture health	3.4	0.8	2.6	4.4	17.3	√	Nil
3. Grazing Management and Productive Systems							
3.1 Pasture and livestock indicators	8.1	1.9	6.2	4.24	16.1	√√	√√
3.2 Livestock system design	10.5	0.8	9.7	13.7	30.0	√√	√√
3.3 Integration of feeds into productive systems	7.9	1.5	6.3	5.13	20.9	√√	√√
Total			**65.5**				

The Sensitivity Analysis shows:

- That across all themes benefits are halved without change in costs.
- All themes continue to generate a positive NPV.
- Theme 2.2 'Pasture and Agronomy Management' offers only modest positive returns.

References

Council of Rural Research and Development Corporations (revised 2009) Evaluation Guidelines

Holmes Sackett (August 2010) Southern Beef Situation Analysis published by MLA

MLA (November 2010 working draft) Summary of Processes Undertaken by the Evaluation Group

MLA (January 2011) Feedbase Investment Plan – RD&E Priorities for the Southern Australian Feedbase

MLA (May 2011) Feedbase R&D Plan Approved Draft