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Farming Systems R&D and Modelling for the Southern Feedbase

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Abstract

This project initially undertook a review of projects planned or taking place under the MLA Southern Feedbase program to identify possible farm systems level issues and questions that may arise when livestock producers and their advisers are considering the adoption of project outcomes. Such questions are related to the likely impacts of project outcomes on whole farm productivity, costs, profitability, risk and sustainability.

Having identified the likely farm systems level issues and questions, the project then analysed the capacity of existing farm systems modelling tools to answer some or all of those issues and questions. Consultation with livestock producers, farm system model developers and users, advisers and consultants to livestock producers, and researchers involved with Southern Feedbase R&D projects, led to the development of recommendations for:

- Maintaining and improving the capacity of farm systems modelling tools to help analyse and report the likely impacts of technology adoption and management change on southern Australian livestock producing farms, and;

The need to undertake farm systems level R&D to improve understanding of the impacts of technology adoption and management change.

Executive summary

MLA commissioned this 'Farming Systems R&D and Modeling' project to examine the following:

1. Identify the farm system level issues and questions that are likely to arise as a result of the conduct of a series of R&D projects that MLA is investing in as part of their Southern Feedbase Program

2. Evaluate the potential for current whole farm system modelling tools to assist in addressing those issues and questions and develop recommendations for improvements in the capacity of those tools.

3. If the modelling tools will not adequately address those issues and questions, develop recommendations for either:
   a. changes to R&D projects to obtain better systems level outcomes, or;
   b. new, systems level R&D and/or farm scale monitoring projects that may need to be conducted.

A significant number of farm systems level issues and questions have been identified following review of R&D project plans and background planning documents for the MLA Feedbase R&D Plan. Consultation with farm systems model developers and users around Australia and review of published outputs from modelling projects has confirmed that existing or updated models would be useful in at least partially answering many of the farm systems level issues and questions likely to arise from Feedbase R&D projects.

Consultation with livestock producers, farmer advisers/consultants and agricultural researchers has identified a number of needs for further development of models to improve their relevance to production systems, pasture and forage species in current use and some production environments. Maintaining human capacity for model development and practical validation and use of model outputs by livestock producers is another priority for the future. Some production systems, most notably cropping/livestock mixed enterprise systems are likely to warrant further investment in on-ground physical R&D and/or commercial scale monitoring.

Recommendations arising from the project:

The following three recommendations are made to MLA following the conduct of this project:

Re-visit Southern Feedbase project plans and integrate modelling into all plans as applicable

It is recommended that:

1. ***MLA negotiate with leaders of all projects planned or proposed in the Southern Feedbase program to seek and ensure that:***
   a. all projects examine the applicability and role of farm systems modelling (see also recommendation 2) to assist their projects meet the desired objectives in the most effective manner

b. data generated in each project will be collected in a form that will be suitable as input data to, or for parameterisation of, whole farm systems models and analysis.
    - Note: it may be appropriate that the Southern Feedbase Governance Committee / Group (to be) established by the RMCiC be charged with this role.

Establish a Farm Systems Modelling Support and Advisory Group

It is recommended that:

2. MLA establish and resource a Modelling Support and Advisory Group comprising a selected group of model developers and experienced model users (from those consulted in this project). This group would be resourced to meet the following needs:

a. Provide advice to Southern Feedbase Program project leaders on the appropriate model(s) of relevance to conduct ex-ante and/or ex-poste whole farm analysis of data likely to arise/actually arising, from each project (see recommendation 1)

b. Identify shortcomings of models to undertake such analysis of project outputs and prioritise the needs for model upgrades; develop recommendations to MLA and other agencies or funding bodies on the resources (financial; human capacity) needed for priority model upgrades, and for human capacity development for the applied use of models.

Consider new Farm Systems R&D in Mixed Farming Zones

It is recommended that:

3. MLA consult with GRDC about the objectives and resourcing of producer groups in mixed farming zones across southern Australia to collect data and monitor key indicators of pasture/livestock/crop performance on commercial farms that adopt (or not) pasture management changes or other innovations.

a. Possible priority locations may be one group in the summer dominant rainfall mixed farming zone of northern NSW/southern QLD; another in southern NSW/northern Victoria and one in the wheat/sheep zone of SW WA, however, these would be the subject of discussion with GRDC.

b. A process, possibly similar to MLA's 'Producer Demonstration Sites' could be used to identify who would be interested to trial and evaluate under commercial conditions, new pasture and forage management strategies and to collect data appropriate for analysis of whole farm system performance.

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1 Introduction

MLA, acting as an agent for the Red Meat Co-investment Committee (RMCiC), developed a Feedbase Investment Plan (the FIP) that followed on from the PISC process of developing national beef and sheep industry RD&E strategies. To build the next level of detail, MLA commissioned the Feedbase R&D Plan which defined 5 key R&D Pillars:

- Pasture breeding & evaluation;
- Productive & sustainable pastures;
- Grazing management & production systems
- Weeds & biodiversity; and
- Decision tools.

In the 'Grazing management & production systems' pillar, the overarching goal is to increase profit by increasing the margin between cost of production and sales revenue for southern Australian meat and livestock producers.

MLA commissioned this 'Farming Systems R&D and Modeling' project to examine the following:

1. Identify the farm system level issues and questions that are likely to arise as a result of the conduct of a series of R&D projects that MLA is investing in as part of their Southern Feedbase Program

2. Evaluate the potential for current whole farm system modelling tools to assist in addressing those issues and questions and develop recommendations for improvements in the capacity of those tools.

3. If the modelling tools will not adequately address those issues and questions, develop recommendations for either:
   a. changes to R&D projects to obtain better systems level outcomes, or;
   b. new, systems level R&D and/or farm scale monitoring projects that may need to be conducted.

2 Farm system level questions likely to arise from Southern Feedbase R&D projects

A review of the Feedbase RD&E Plan, available project plans and numerous background documents has identified many issues and questions at the farm systems level that require consideration.

Some of these questions are related to clarifying the underlying hypotheses and rationale for the conduct of R&D projects within the 5 pillars of the Feedbase Program. A key focus of this project was to consider “What questions would leading livestock producers or their advisers ask about the results of R&D, when they are trying to decide whether to adopt the information, innovations or new species / cultivars arising from the R&D?”

These questions have then been put to the 'modellers' and clarification sought on "can your model answer this question; or what information would you need to enable your model to answer this question"?

If models are unable to answer such questions then there is a case that either the R&D should be modified to get that answer, or that further investment is needed in systems level R&D or on-farm monitoring to help answer the questions.

Some of these issues and questions arise at a 'pillar' level, while others arise from the specific objectives and plans of projects under development within pillars.

Pillar 1: Plant breeding and evaluation (Focus – Pre farm gate)

Background planning for the Feedbase Program has identified two priority themes for possible investment in plant breeding:

- Pasture legumes - tolerance to low pH and/or low P; performance in mixed swards; adaptation to shorter/more variable seasons; role in sub-tropical grass mixes
- Pasture grasses-reduced toxicity; better aluminium tolerance; adaptation to shorter/more variable seasons; role of subtropical species

Questions:

1. What are the priority breeding objectives for new pasture cultivars? Can existing farm systems models be used effectively to help determine the priorities for improvement (breeding objectives) in cultivars within existing pasture species?
2. Pasture cultivar/variety trials in different production environments produce data on variables such as growth (including seasonality), quality and persistence. Can the information from pasture cultivar/variety trials be used in farm systems models to calculate differences in profitability of grazing enterprises using different sown cultivars?
3. Are there new / niche / novel pasture or forage species that have the potential to increase profitability of grazing enterprises in some regions?

Pillar 2: Productive and sustainable pastures (Focus – In paddock)

There are a wide range of issues and priorities for possible R&D in this pillar that have been raised in background planning for the Feedbase Program. These include:

- Pests and diseases of pastures and interactions with soil fertility-particularly for pasture legume production and persistence
- Utilisation of tropical grass and legume species in new regions
- New approaches to integrating pasture legumes in cropping/grazing systems.

Questions:

1. How can producers better manage the existing pasture base to improve pasture production and quality with enhanced legume and perennial grass content - so as to better address feed gaps and seasonal variability?
2. What is the most effective and profitable way to increase pasture production –change cultivar/species grown or increase soil fertility or improve fertiliser precision or improve soil biology?

3. Will novel management interventions to reduce the prevalence and impacts of soil borne diseases on pastures (particularly annual legume cultivars) lead to significant change in livestock productivity and profitability?
4. Do some pasture legume and grass cultivars produce more than others on low P soils and what would their impact on whole system profitability in low P regions compared with P fertiliser inputs for existing pastures in those regions?
5. Will the sowing of specific tropical grass/legume mixes on different soil types, under different livestock production systems in key southern meat producing regions, address pasture production and feed quality limitations in those regions-particularly summer/autumn feed deficits?
6. What is the potential to increase legume pasture productivity during the pasture phase of mixed farming (cropping/grazing) systems in different regions and what are the livestock production and cost of production impacts of increased legume presence in the pasture phase?
7. For the various pasture management interventions listed above, what are their likely impacts on risk and year-on-year volatility of returns for livestock producers?

Pillar 3: **Grazing Management and production systems** (Focus – Multi paddock/farm scale)

There are currently two main areas for consideration of R&D investment in this pillar:

- Production and profitability impacts of dual purpose crops under a range of livestock production systems in a range of southern regions.
- The feasibility of “remote data collection and precision technologies” for livestock production systems.

Questions:

1. What trigger points or indicators should a producer use under different grazing regimes to match stocking rates and pasture utilisation goals across different systems and regions to increase profit and deliver NRM benefits?
2. What are the risks, production, income and costs implications of different grazing enterprises on farms with/without dual purpose crops?
3. What are the possible ranges of benefits and costs of using different remote data collection and precision technologies under different livestock production systems in different regions? Could modelling be used to pre-test the possible feasibility of these technologies, and their potential impacts on utilisation of pastures, labour costs, stocking rates etc., before further investment in testing or developing the technologies for use by livestock producers?
4. What is the real value (costs and benefits) of fodder conservation and/or containment feeding to improve the overall feedbase and animal performance and to also reduce soil and pasture degradation?

3 An Inventory of Models relevant to MLA's Southern Feedbase Program

An inventory of relevant "farm system models" available for feedbase research, analysis and extension was compiled and an assessment made of existing capacity in model development and use.

Information compiled in this report has been derived from numerous sources including:

1. Review of relevant published literature, including (but not limited to):
   - Climate risk management tools for the Managing Climate Variability program (Creighton et al 2009)
   - Identifying the value of pasture improvement using whole farm modeling (Bathgate et al 2009)
   - Evolution of the GRAZPLAN decision support tools and adoption by the grazing industry in temperate Australia (Donnelly et al 2002)
   - Seeking simultaneous improvements in farm profit and natural resource indicators: a modeling analysis (Robertson et al 2009)
   - Analysis of the profitability of sheep wool and meat enterprises in southern Australia (Warn et al 2006)
   - Evaluating pasture breeding objectives using computer models (Donnelly et al 1994)
   - Decision support tools: keys to success (Moore 2007)
   - Johnson (2012) SGS Pasture Model and DairyMod - an overview
2. A review of websites and details of specific models
3. Consultation with both model developers and users of them

Applicable models can best be categorised into two sub-sections:

a. Research models
b. Other models (decision support tools)

The focus of this section is predominately on research models.

3.1. Research Models

Over-arching suites of models

APSIM (Agricultural Production Systems Simulator)

APSIM is internationally recognised as a highly advanced simulator of agricultural systems. It contains a suite of modules which include a diverse range of crops, pastures and trees, soil processes including water balance, N and P transformations, soil pH, erosion and a full range of management controls. APSIM resulted from a need for tools that provided accurate predictions of crop production in relation to climate, genotype, soil and management factors while addressing the long-term resource management issues. It is undergoing continual development, with new capability added to regular releases of official versions over time. Its development and maintenance is underpinned by rigorous science and software engineering

standards. There are specific tools such as YieldProphet and WhopperCropper which are easy to use web interfaces for APSIM that are used by many consultants and growers around Australia.

The APSIM initiative (AI) has been established to promote the development and use of the science modules and infrastructure software of APSIM. The Foundation Members of the AI are CSIRO, DPI Queensland and The University of Queensland. New parties are welcome to join at any time. The AI is managed by a Steering Committee, with a Reference Panel providing advice on matters relating to APSIM development, in particular science quality and software development.

GRAZPLAN

The GrazPlanproject at CSIRO Plant Industry has developed a series of computer models that are the basis of three commercially available decision support (DS) tools - GrassGro, GrazFeed and AusFarm. These tools are intended to help farmers to make decisions about their farm management based on findings from scientific research. They are aimed not only at farmers and farm advisors, but also at industry organisations, agribusiness, banks and insurance companies.

3.1.1. Specific Models

- **GrassGro**

Is a biophysical grazing systems model focussed on the wool and meat (sheep and beef) industries in southern Australia. It is largely applicable for sown pasture to address questions such as best time for lambing / calving; appropriate stocking rates; and likely gross margins. GrassGro can quantify the variability in pasture and animal production in response to climate and management changes so that farmers and natural resource managers can assess the profitability impacts and risks that variable weather or changing management systems imposes on a grazing system.

GrassGro is probably the strongest model in animal production, but it has a limited range of pasture species parameterised, although this is increasing. It uses daily climate data(via an automatic download of climate data from the BOM for the nearest weather station), and characteristics of the grazing property (soil profile characteristics and moisture holding capacity, pasture species) and animal enterprise (including genotype, production system and grazing management system including rules for the feeding of supplements).

Seasonal and year-to-year variation in pasture and animal production and gross margins are presented in comprehensive reports which enables some analysis of risk associated with climate and management decisions.

Strengths	Weaknesses
Can be applied to a wide range of regions/climates/soil types	Need to nominate a fixed stocking rate strategy i.e. no capacity to evaluate within year stocking rate adjustment
Readily enables comparison of profit and risk impacts of alternative grazing enterprises, pasture types, grazing management options	Limited capacity to deal with mixed farming (cropping/livestock) systems
Biophysical modeling of a range of livestock systems in a range of environments	Not parameterised for some pasture types in which there is increasing interest from leading producers in some regions (native perennial grasses, subtropical grass and legume species, shrubs such as saltbush, more recent cultivars of some species such as phalaris and lucerne)
Strong animal model (especially sheep) although some need to update parameter sets for modern genetics (but does not cater well for individual animal variation in growth)	Does not fully account for soil/plant nutrient cycling.
	Does not account for persistence/plant death/changes in pasture composition
	Economic analysis limited to gross margins per hectare with limited functionality to test impacts of price variability in inputs and outputs. Does not account for labour and technology application costs
	Limited capacity to handle different grazing management options and impacts on pasture dynamics

- **GrazFeed**

GrazFeed helps farmers save supplementation costs and reach livestock production targets by calculating the daily nutritional requirements of sheep and cattle. It is an up-to-date and user-friendly computer version of the Australian Ruminant Feeding Standards that can be applied to any breed or class of sheep and cattle and takes into account the effects of selection and substitution by grazing stock. GrazFeed can be applied to any temperate or tropical grazing system where sheep or cattle graze pasture, rather than browse shrubs. It can also accommodate management systems which restrict pasture intake, such as strip grazing, cut-and-carry systems and feedlotting.

A far simpler program than GrassGro, GrazFeed takes into account the type of animal, the availability and quality of pasture, selective grazing and interaction with supplementary feeds

(for example the substitution of supplement for pasture) then predicts the live weight change of the animals being described after estimating, where appropriate, foetal growth, milk production, growth weight of unweaned young and wool growth.

Strengths	Weaknesses
Easier to use than models such as GrassGro	More of a decision support tool rather than applicable to examine research questions
Can be used to assess possible responses due to feed quality	Differences due to modern animal genetics are not available and/or efficiency can't be tested
Point in time feed budgeting and animal performance tool	Does not account for persistence/plant death/changes in pasture composition

- **AusFarm**

AusFarm is essentially a linking of APSIM, GrassGro and other component models and, as such, goes several steps further than GrazFeed and GrassGro in the description of complex biological systems by optimising management strategies for livestock, grassland and cropping operations on a mixed farm or across a variable landscape.

Its structure allows models of farm components to be configured and co-ordinated with an infinitely flexible set of management rules. AusFarm's modular design means that it can include models from other scientific groups. This greatly expands the number of crop, livestock and management systems that can be represented and analysed. AusFarm is primarily used by experts for large projects and research, focused on the dryland mixed grazing/ cropping farming systems in southern Australia.

Strengths	Weaknesses
Capacity to model mixed farming systems	Not user friendly (not for use by farmers/advisers)
Can accommodate flexible within-year stocking rate strategies.	Does not account for persistence/plant death/changes in pasture composition

➢ SGS Pasture model (including DairyMod)

The SGS Pasture Model and related DairyMod and EcoMod are mechanistic biophysical pasture simulation models. The models include pasture growth and utilisation by grazing animals (up to 5 pasture species in any simulation - annual, perennial e.g. C3 or C4 and legumes), animal metabolism and growth (sheep, beef cattle and dairy cows), water and nutrient dynamics (N, P, K, S and soil organic matter), and options for pasture management, irrigation and fertilizer application.

The underlying processes in these models are identical but they have livestock and management systems customised for different industries:

- DairyMod for dairy;
- SGS Pasture model for sheep and beef; and,
- EcoMod (primarily used in New Zealand) for dairy, sheep, beef and deer systems.

These models can be used to investigate climate and management impacts on pasture and animal production in point-based simulations. They have been used to simulate sown and native pasture based systems from SW Western Australian to SE Queensland. To date, these models have mostly been used within the agricultural systems research community.

Strengths	Weaknesses
Broader pasture species base than GrassGro, including some native species	Weaker interface with animal production responses compared with GrassGro
Takes good account of soil/plant nutrient cycles	Does not account for persistence/plant death/changes in pasture composition
Ability to more easily adjust responses (e.g. pasture growth) than other models	Has economic interface but reportedly not as strong as GrassGro or MIDAS

➢ MIDAS

The MIDAS (Model of an Integrated Dryland Agricultural System) computer models represent the economics and biology of farming in various regions in the grain and sheep belts of Western Australia. Subsidiary MIDAS models have been developed for 4 regions in southern and central NSW, 2 regions in Vic and 1 region in SE SA. Each model includes components for crops, pastures, sheep, stubble, grain feeding, machinery and finance. They are strongly based on soil types and rotations, with different production figures for each rotation on each soil type.

MIDAS are not simulation models. Rather, given a set of production relationships provided by the user, they will calculate optimal farm management practices including rotations, flock structure, stocking rate and feeding strategies. MIDAS is based on linear programming techniques.

The models select strategies which maximise profits in the medium term which is considered to be 3-5 years. An assumption in MIDAS is that every season is an "average" season, therefore differing from programs such as GrassGro.

Strengths	Weaknesses
Well placed to calculate whole farm profitability impacts of new pasture cultivars, fodder crops or supplementary feeding strategies and the optimum portion of the farm to be sown or devoted to a new management strategy.	Uses 8-12 week seasonal average climate data-hence limited capacity to deal with seasonality or making day to day tactical management decisions. Can't analyse production risk as uses average pasture curves
Very strong sheep model with ability to test impacts such as management of condition score	Not readily applied to new regions
Very strong optimization model	Not useful in analyzing risks associated with decisions about adopting new technologies or management strategies.
	Quite complex - and predominately used in WA (extensively used in FFI CRC for EverGraze, Enrich. Also Sheep CRC and other modeling for lifetime wool).
	Does not account for persistence/plant death/changes in pasture composition
	Cattle production not well developed
	Not useful for analyzing year in, year out (carry over) effects from pastures and production systems

3.1.2. Other specific models - less applicable to Southern Feedbase

- **AussieGRASS**

AussieGRASS predicts grass production at a continental scale and with 3 month out looks based on SOI. It has been operational since 1996. It is applicable to grazing in the rangelands (@5 km grids) and not of great use for southern red meat production.

- **GRASP (Grass Production Model)**

Investigates soil water, pasture growth, grazing and perennial shrub and tree interactions, especially in tropical and subtropical Australian native and improved pasture systems

Essentially a research tool, it is not relevant for southern red meat production systems

3.2. Other Models (decision support tools)

MLA and other R&D Corps have invested in the development of an array of producer focussed decision support system (DSS) tools which have some relevance to assisting broaden adoption of RD&E outcomes.

These include:

- Cost of production calculators
- Feed demand calculator
- Feed budget and rotation planner(e.g. Prograze)
- Rainfall to pasture growth outlook tool
- Pasture improvement calculator
- Phosphorus tool

There is also a remote sensing tool, largely focused on Western Australian systems detailed below.

- **Pastures from Space**

Pastures from Space provides near real time estimates of pasture production, by utilising satellite data and modelling approaches and tools to support grazing decisions, predominately in SW Western Australia. Key decisions that can be informed include grazing pressure, stocking rates and deferment times. Satellite images are used to estimate the biomass of pasture at a paddock to whole of farm scale, with modelling techniques based on local weather used to fill in times between satellite images. It requires animal type and number to be entered plus estimates of feed on offer.

- **FARMAX (NZ)**

A commercially available program that is widely used in NZ by farm management consultants is a decision support tool (physical and financial benchmarking) for farmers. It seeks to expose (under various scenarios) how farmers can most effectively convert pasture into profit. It has a licence fee of approximately $3,000 p.a. To date Farmax has only had limited exposure (and validation) in Australia. Rather than predicting pasture growth (as per GrassGro), Farmax derives pasture growth via an assessment of Dry Matter / Ha plus animal weight gains.

4 Applicability of models to farm systems level questions

The following table seeks to provide an overview of how well, or otherwise, current models can provide answers to the farm systems level questions which will or may arise from the Feedbase R&D plan and which have been outlined in section 2 of this report. An indication of their relative strength in this regard is provided by background highlighting in the 'RD&E Questions' column where:

= models not currently relevant / useful

= models useful addition

= models highly relevant / useful

RD&E Questions	Relevance of Models
Pillar 1 - plant breeding and evaluation	
• Priorities for improvement in cultivars of existing pasture species	Models have been used in this capacity. The paper by Donnelly et al (1994) discussed how models within the GrazPlan suite are able to illustrate how pastures with different characteristics (e.g. greater winter growth, reduced maturation, more legumes) can impact on animal productivity. Recent work using SGS has also illustrated how altering pasture characteristics (heat tolerance, deeper rooting) may help production under future climates. Need to take a 20-30 year perspective when modelling the relative importance of different breeding objectives for new cultivars.
• Pasture cultivar/variety performance in different production environments	None of the models simulate persistence. It may best be incorporated into economic models as a cost to re-sow pasture at certain intervals relative to persistence. Many pasture cultivar/variety trials have yield/quality data derived from small plots and hand harvesting. Difficult to extrapolate to performance under grazing. However, as above, altering the characteristics of pastures and its impact on productivity of livestock can be modelled. More comprehensive variety trials will be needed to develop new pasture variety parameter

	sets and/or validate models
a. Pasture legumes - tolerance to low pH and/or low P, performance in mixed swards, adaptation to shorter/more variable seasons; role in sub-tropical grass mixes;	One or more models can simulate these factors
b. Pasture grasses - reduced toxicity, better aluminium tolerance, adaptation to shorter/more variable seasons; role of sub-tropical species.	Unlikely that any models are able to simulate factors such as aluminium tolerance or toxicity, although derived pasture response curves can give an indication of potential. Adaptation to shorter growing seasons can be modelled
• Role of new / niche / novel species in specific locations	Models such as SGS and GrassGro can help assess the impact but still require field data to validate results. As above, need to have sufficient agronomic data and development of a parameter set to describe the new species models can test
Pillar 2 - productive and sustainable pastures	
• Manage the existing pasture base to improve pasture production and quality with enhanced legume and perennial grass content	Models struggle to accurately simulate changes in pasture composition and persistence. Past projects such as SGS/TPSKP and EverGraze are likely to have generated data that could be used to build and verify models to evaluate the impacts of different management techniques on persistence, productivity and quality. However, timescale of data is a limitation
• What is the most effective and profitable way to increase pasture production –change cultivar/species grown, increase soil fertility, improve fertiliser precision, improve soil biology	Much is already known in this space and available from other information sources Improving soil fertility and application / timing of fertiliser treatments can be modelled but unclear if models are able to examine soil biology (except perhaps SGS by changing soil carbon) Soil biology could also be incorporated into economic analysis with a model such as MIDAS by simply doing a sensitivity analysis- for example if data exists to demonstrate

	management action to change soil biology increased production by 10%, what would it be worth to farm profit? If likely increase in production/stocking rate from sowing versus more fertiliser is known then can use discounted cash flow budgets/net present value methods to compare investment options –rather than use MIDAS.
• Novel management interventions to reduce the prevalence and impacts of soil borne diseases on pastures	Unable to model soil pathogens but can be simulated by increasing pasture production if you have experimental data from field testing.
• Do some pasture legume and grass cultivars produce more than others on low P soils and what would be the overall impacts on whole system profitability in low P regions compared with P fertilizer inputs for existing pastures	Would require the use of AusFarm or SGS pasture model plus economic analysis if raw data available Comparison of better plants or better soils can be assessed but need GMs or NPVs to assess the economics. Note, it will be important to evaluate the animal production impacts of variable levels of P content in forage produced, not just the variable levels of plant biomass produced.
• Role of specific tropical grass/legume mixes in key southern meat producing regions to address pasture production and feed quality limitations	Models are capable of doing this however for GrassGro & AusFarm it requires the development / availability of parameter sets for most species. The models would also require validation for some regions and soil types. SGS pasture model has capability
• Potential to increase legume pasture productivity during the pasture phase of mixed farming (cropping/grazing) systems in different regions	AusFarm
• For the various pasture management interventions listed above, what are their likely impacts on risk and year-on-year volatility of returns for livestock producers.	A strength of models is they can be run historically over long periods of time and therefore give a measure of risk and volatility from year to year. All have simple gross margin analysis so can give some economic measure as well, although the economic analysis needs to extend beyond simple, within year gross margins. There is a need to develop “common language” or clearer definitions of risk to enable more meaningful modelling of risk.

Pillar 3 - grazing management and production systems	
• Trigger points or indicators for producer use under different grazing regimes to match stocking rates and pasture utilisation goals across different systems and regions to increase profit and deliver NRM benefits	Some trigger points or indicators can be included in the management regime within the models. AusFarm can probably include most-the other models would be somewhat more limited. Models could certainly tackle some of this question although trigger points are likely to vary widely for different enterprises and different regions. Some preliminary work with SGS has explored the medium term forecast of pasture production but is limited by accuracy of seasonal forecasts NB: key trigger points relating to sustainable stocking rates/levels of utilisation are well understood e.g. % ground cover and pasture mass (kg DM/ha green or dead at different times of year). Can specify limits for ground cover or kg DM/ha when running different stocking rates thru models like GrassGro.
• What are the risks, production, income and costs implications of different grazing enterprises on farms with/without dual purpose crops?	Requires AusFarm and economic models to tackle this question. See earlier comment about need to standardise definitions of the indicators of risk.
• What are the possible ranges of benefits and costs of using different remote data collection and precision technologies under different livestock production systems in different regions	Biophysical models could assess potential benefits of these technologies as a guide to determining if further investment in them is warranted (in the light of the likely cost to implement the technologies). Modelling also useful to extend the range of seasons, regions or livestock production systems under which the technologies are evaluated.
• Value (costs and benefits) of fodder conservation and/or containment feeding to improve the overall feedbase and animal performance and to also reduce soil and pasture degradation	Fodder conservation would require the use of AusFarm. Containment feeding could be run in GrassGro as well as AusFarm. Quantifying soil and pasture degradation would be a challenge although this is being addressed in an existing Grain and Graze project.

5. Outcomes of industry workshop

On 12th July 2012, a workshop was held in Sydney, involving 13 invited livestock producers, consultants/advisers, model developers, model users and agricultural researchers. Attendees were sent a background discussion paper (a draft of this report) and were engaged in workshop discussions of

- priority farm systems questions and issues of relevance to the feedbase for southern Australian livestock production systems;
- farm systems model capabilities in dealing with these feedbase issues and questions, and;
- the needs for any farm systems level R&D related to these feedbase issues and questions.

Clarification was sought on the definition of 'farming system level questions and the role of modelling. The following was offered as an example:

- *"we have data on the impact of a new species or pasture management practice at location A and location B. Can we use farm system models to predict the impacts on farm productivity, costs and profitability of that new species or pasture management practice at location C without having to undertake specific research there (which can be expensive)"*

Participants – key feed base issues and questions for southern Australia livestock production systems

- Adoption of new pasture legumes in cropping zones.
- Improved forward predictions (during winter) of spring / summer pasture production so that stocking rate can be better matched with feed supply
- Producers wary of models
- Seasonal and year to year variation in feed supply and better matching of stocking rate to feed base
- How to get adoption when multi-dimensional issues impact on each producer - pasture & livestock production data, economic impacts, social & personal goals, risk profile, capacity etc
- All producers have different goals - getting the balance right. Self- sustaining farms. Focus on soils and reducing energy and fertiliser inputs
- Matching stock to feed availability - is Gross Margin the right indicator for business profitability. Better Decision Support tools for soil factors other than P
- Building diversity into the feed base will increase grazing enterprise resilience and options to respond to climate/seasonal variability
- Refine risk / reward of strategic and tactical decisions. Modelling key to advisory staff development
- Soil pathogens contribute significantly to variation in plant survival and productivity. Need to build cultivar/species persistence into models
- How to increase phosphorous efficiency of pastures, particularly legumes
- Intensification of grazing systems - sustainably. Compare systems over 10 to 20 year time-frame
- Converting paddock based decisions into ones best for overall enterprise

Case study of Farming Systems R&D and associated modelling-EverGraze

Workshop attendees were presented with an overview of the EverGraze project as a case study of a national scale farm systems R&D project focussed on pasture production, management, profitability and environmental impacts. Pre- and post-experimental modelling has been used to plan some of the research components and to attempt to broaden the outcomes of the R&D both spatially and temporally, and to develop decision support tools for producers/advisers. Key learnings from the EverGraze project contributed to workshop discussions and outcomes as presented in the following sections of this report.

Priorities – key farm systems level feedbase issues and questions

Two groups of workshop attendees discussed the priority farm systems level feedbase issues and questions for southern Australia livestock production systems. The outcomes are summarised below. Similar issues are highlighted:

Group 1	Group 2
1. Root health ⟶ Persistence. Systems approach to understanding the drivers • disease • nutritional access • damage (e.g. herbicides) • impact of grazing management Impacts likely to be greatest in annual systems	1. How does innovation / technology / intervention impact on the farm system
2. Energy / inputs - aim to lower inputs and achieve more efficient use of resources	2. Intensification - not necessarily increasing inputs, but greater efficiency of resource use
3. Cost to maintain pasture base • fertiliser inputs • sowing new species	3. Understanding and managing variability - seasonal and other
4. Better manage seasonal variability - will be big differences between permanent pastures and mixed farming systems	4. Setting production system targets (potential levels?)
5. Better manage interventions to achieve a sustainable production system	5. Making paddock decisions that maximise profit for the enterprise • next best investment • risks of different options
	6. Use models to analyse the impacts of changes that can't be trialled (e.g. climate change)

The role of farm system models

Workshop participants contributed their views on the roles and capabilities of farm systems models in addressing these priority issues and questions:

- The priority is to have models with the capability to predict outcomes, based on solid science
- Models currently lack capabilities in the following areas
  - root pathogens
  - species composition changes
  - persistence
  - data on some new species / cultivars
  - Phosphorous cycling
  - interactions between soil elements –P, K, N, S, C, water
- Need long term solution for updating models and for training / support of model users
  - Need better accessibility to models to allow testing of data for new species / cultivars/ management options
  - Need better guidelines for casual model users such as extension officers/consultants
  - Casual users need access to skilled users / trainers
  - Shortage of skills to use models
  - Shortage of resources to input existing and new data
- Do Gross Margins provide sufficient information to evaluate the pros and cons of new technologies or management changes? Should economic parameters be expanded
- IP barriers to sharing research data need to be removed

General position –establish a farm systems modelling "Bureau"

- Would need to include training provision, easy access to case studies, help desk and resources to update models as new data becomes available
- Include all models (e.g. GrassGro and SGS)
- Long term solution - but difficulty of continued funding is recognised
- Build funding for "bureau" activities in to broader project applications

The role of farm systems R&D

Workshop participants contributed views on possible needs for farm systems "on-ground" R&D and/or farm monitoring projects to address some of the priority issues and questions.

General position

a. *Identify the key questions that need answering,*
b. *Examine what data already exists (both public and private)*
c. *Perform gap analysis to identify what R&D is needed*
d. *Prioritise needs*

On balance the highest priority appears to be:

- Long term grazing trials in mixed farming zones
  - would need to be done with GRDC
  - difficulties recognised - difficult experiment to do
  - is it R or D or both that is needed
  - clearly define the questions first
  - examine both high and low input systems
- An alternative is to look at component 'research' (usually farmer trials) that no doubt exists on many commercial farms already and analyse this first
  - is already happening for cropping

6. Conclusions-needs for future farm systems R&D and/or modelling

It should be noted that many of the proposed/possible projects under the Southern Feedbase Program are at a relatively early stage of planning. Hence it is difficult to propose a complete list of likely farm systems level questions (and thus 'solutions') which may arise from R,D&E projects within the program.

Consultation with industry experts across a range of relevant fields, the industry workshop and review of relevant publications has indicated:

- Models and 'field data' should be seen as complimentary, not 'either / or'.
- Existing farm systems models and some simpler decision support tools, have the potential to provide at least high level answers to a large proportion of the farm systems level questions identified from the Feedbase projects plans.
- While farm consultants/advisers see the potential for models to “answer” farm systems level questions at a high level, there is a widely held view of the need for robust physical data sets derived from on-ground grazing systems R&D, to validate model outcomes and to give leading livestock producers the confidence to adopt management changes.
- While existing models have many outstanding features, further development of them to increase their scope of application and ease of use was strongly supported.
- There is a shortage of skilled personnel at two levels:
  i. For further development of existing models.
  ii. For validation of models at a practical farm level and for facilitation of the use of model outcomes by leading livestock producers.

Specific needs identified

1. Model Development and Use

a. Further develop Ausfarm as a more user friendly tool for use by advisers/consultants to help livestock producers make more complex management decisions, particularly in southern mixed farming regions.

(Rationale: There is a gap in knowledge/model availability at the livestock cropping interface. This is an important area for red meat production in Australia and potential climate change will produce greater challenges in this area)

b. Train advisers/consultants in the use and application of Ausfarm, GrassGro and/or SGS Pasture model.

(Rationale: Capacity to use models is limited. Experience in other projects indicates that the build-up of such capacity is very important for advisors and producers alike. Similarly, the applied use of models by skilled advisors/consultants provides a valuable "feedback loop" for model developers about the practical relevance of the model tools and validation of modelling outcomes)

c. Post-graduate training and professional development of appropriately skilled professionals capable of development and updating of existing models.

(Rationale: Capacity to develop/refine models is very limited)

d. Dedicate a resource to capturing farm system data that has been produced from previous / existing programs and make available for model incorporation.

(Rationale: For a range of reasons-including IP ownership-there appears to be data in existence that has not yet been incorporated into models)

e. When field trials are being designed, take consideration of information capture so as data is applicable to incorporate into models.

(*Rationale: There are subtle differences between data coming from some research trials and data that can be incorporated into models. Paddock scale data collected under commercial grazing conditions will be more relevant than research plot data. Understand the needs up front so that outputs can be better utilised)*

f. Consider the establishment (re-establishment) of a major modellers group to increase co-operation between the various research models

g. Develop model components with specific emphasis on:

i. Prediction of persistence of different species/cultivars and pasture composition change under different grazing strategies

ii. Predicting feed intake and grazing selectivity in mixed swards

iii. Develop parameter sets for species not adequately represented in (some) models-specifically for subtropical grasses, tall fescue, native perennials

iv. Prediction of changes in pasture seed banks under cropping rotations

v. Improved accounting for genetic change in livestock performance

vi. Phosphorous cycling and interactions between soil P,K,N,S,C and water

(Rationale: These developments address some of the specific weaknesses of current models identified in sections 3 and 4 of this report. As noted above -wherever possible, utilize existing data sets from past and existing R&D projects to develop and validate these new model components).

2. Farm Systems R&D

In relation to requirements for farms system R&D the following needs exist:

a. Long term (minimum 6 years) grazing trials/demonstrations of new pasture types/mixes and grazing management systems in regions not covered by previous R&D -most notably in mixed farming zones where livestock numbers and priority on livestock as part of the farm business mix, may increase in the next decades. Consider evaluation of contrasting high and low input production systems.

(Rationale: Consultation and review of model capabilities has indicated less confidence in the outcomes of current farm systems models for mixed livestock/cropping zones. Long term grazing trials/demonstrations in such zones would serve the following purposes:

- *Generate data to strengthen and validate models of such mixed enterprise systems*
- *Increase the confidence of advisors and leading producers in those regions in model outcomes and use-as has been the case in higher rainfall/permanent pasture regions where such long term grazing trials/demonstrations have been predominantly conducted under previous programs)*

b. Review high rainfall zone trials to assess availability of data for persistence and composition over the long term.

c. Identify existing data sets and, if necessary, implement on-farm monitoring of persistence and pasture composition change in “permanent” pasture and mixed farming zones.

d. Use data generated in these trials/demonstrations to develop and validate farm systems models relevant to those regions and production systems.

7. Recommendations

The terms of reference for this project directed the development of recommendations covering the following:

- What project level activity is needed in the Southern Feedbase program to deliver on systems level questions
- What development process MLA should apply in order to develop the project or projects that are needed
- How such R&D should be linked to the component projects

The following three recommendations are made to MLA following the conduct of this project:

Re-visit Southern Feedbase project plans and integrate modelling into all plans as applicable

It is noted that a number of planned Southern Feedbase projects have explicit plans to generate data on impacts of management changes or other project outputs on livestock productivity, farm income, costs and profitability. In fact, at least one project proposes to subject project output data to whole farm systems analysis using one of the models reviewed in this project. Other projects have general plans to engage livestock producers in the commercial scale testing, monitoring and demonstration of management changes and other innovations arising from R&D project activities.

It is recommended that:

1. ***MLA negotiate with leaders of all projects planned or proposed in the Southern Feedbase program to seek and ensure that:***
    a. all projects examine the applicability and role of farm systems modelling (see also recommendation 2) to assist their projects meet the desired objectives in the most effective manner
    b. data generated in each project will be collected in a form that will be suitable as input data to, or for parameterisation of, whole farm systems models and analysis.
        - Note: it may be appropriate that the Southern Feedbase Governance Committee / Group (to be) established by the RMCiC be charged with this role.

Establish a Farm Systems Modelling Support and Advisory Group

A large number of needs have been identified in relation to the 'user friendliness' and scope of existing farm systems models, and in the capacity of people to either further develop them or use them as tools at the producer interface. However, there is no forum available to progress any of these gaps.

It is recommended that:

2. ***MLA establish and resource a Modelling Support and Advisory Group comprising a selected group of model developers and experienced model users (from those consulted in this project). This group would be resourced to meet the following needs:***

   a. Provide advice to Southern Feedbase Program project leaders on the appropriate model(s) of relevance to conduct ex-ante and/or ex-poste whole farm analysis of data likely to arise/actually arising, from each project (see recommendation 1)

   b. Identify shortcomings of models to undertake such analysis of project outputs and prioritise the needs for model upgrades; develop recommendations to MLA and other agencies or funding bodies on the resources (financial; human capacity) needed for priority model upgrades, and for human capacity development for the applied use of models.

Consider new Farm Systems R&D in Mixed Farming Zones

To improve current and future feed base productivity and profitability of livestock production in a large part of southern Australia, there is a need for long term (minimum 6 years) grazing trials and/or demonstrations of new pasture types and grazing management systems in mixed farming zones of southern Australia. Such R&D should be planned and resourced as a collaborative venture between MLA and GRDC.

It is recognised that the logistical challenges of such work in the more complex management systems on cropping/grazing mixed farms are significant. Hence, an alternative to “normal”, replicated R&D trials of management changes under such systems is to resource producers/ producer groups to collect data and monitor key indicators of pasture/livestock/crop performance on commercial farms that adopt(or not) pasture management changes or other innovations (new cultivar mixes; new soil biology treatments; dual purpose crops etc) and to utilise whole farm systems models to analyse such data.

It is recommended that:

3. ***MLA consult with GRDC about the objectives and resourcing of producer groups in mixed farming zones across southern Australia to collect data and monitor key indicators of pasture/livestock/crop performance on commercial farms that adopt (or not) pasture management changes or other innovations.***

   - Possible priority locations may be one group in the summer dominant rainfall mixed farming zone of northern NSW/southern QLD; another in southern NSW/northern Victoria and one in the wheat/sheep zone of SW WA, however, these would be the subject of discussion with GRDC.
   - A process, possibly similar to MLA's 'Producer Demonstration Sites' could be used to identify who would be interested to trial and evaluate under commercial conditions, new pasture and forage management strategies and to collect data appropriate for analysis of whole farm system performance.

Appendices

1. List of those consulted for the project

Farming Systems R&D and Modelling for the Southern Feedbase - Consultation List		
Name	**Organisation**	**Location**
Geoff Saul		Hamilton, Victoria
Jim Shovelton	MS&A	Euroa, Victoria
Peter Bailey	Victorian DPI	Ararat, Victoria
Sandy McEchearn	Holmes Sacket	Wagga Wagga, NSW
Lisa Warn	MacKinnon Project, University of Melbourne	Melbourne, Victoria
Brendan Cullen	University Of Melbourne	Melbourne, Victoria
Natalie Brown	University Of Melbourne	Melbourne, Victoria
Ian Johnson	IMJ Consulting	Melbourne, Victoria
Phil Graham	NSW DPI	Yass, NSW
Andrew Moore	CSIRO	Canberra, ACT
Paul Sanford	WA Dept of Agric	Albany, WA
Andrew Bathgate	Farming Systems Analysis Service	Albany, WA
Suzanne Boschma	NSW DPI	Tamworth, NSW
Martin Barbetti	University of WA	Perth, WA
Richard Simpson	CSIRO	Canberra, ACT
John Howieson	Murdoch University	Perth, WA
Ralph Behrendt	DPI Victoria	Hamilton, Victoria
Dave Henry	CSIRO	Werribee, Victoria
Dean Revell	CSIRO	Perth, WA
Kate Sargeant	DPI Victoria	Benalla, Victoria

Rob Kelly	Producer	Guyra, NSW
Ben Ryan	Producer	SA
Peter Horwood	Producer	WA
Greg Bender	Grapevine Consulting	
Stuart Kemp	Pasture Wise Pty Ltd	
Warren Mason	RPC Solutions Pty Ltd	Orange, NSW

2. Publications Reviewed

Creighton et al (2009). Climate risk management tools for the Managing Climate Variability program

Bathgate, A., Revell, C. and Kingwell, R. (2009).Identifying the value of pasture improvement using whole farm modeling. Agricultural Systems 102:48-57

Donnelly, J.R., Freer, M., Salmon, L., Moore, A.D., Simpson, R.J., Dove, H. and Bolger, T.P.(2002). Evolution of the GRAZPLAN decision support tools and adoption by the grazing industry in temperate Australia. Agricultural Systems 74:115-139

Robertson, Michael, Bathgate, Andrew, Moore, Andrew, Lawes, Roger and Lilley, Julianne. (2009). Seeking simultaneous improvements in farm profit and natural resource indicators: a modeling analysis. Animal Production Science 49: 826-836

Warn et al (2006). Analysis of the profitability of sheep wool and meat enterprises in southern Australia

Donnelly, J.R., Freer, M. and Moore, A.D. (1994).Evaluating pasture breeding objectives using computer models. New Zealand Journal of Agricultural Research 37: 269-275.

Moore, A. (2007) Decision support tools: keys to success

Johnson (2012) SGS Pasture Model and DairyMod - an overview