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Final Report: **Ex-Ante Impact Assessment:**

An Economic Analysis of the Impact of Improved Phosphorus Use Efficiency and Increased Pasture Production in the Beef and Sheepmeat Industries in the Southern Grazing Zone of Australia

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

partner

Abstract

MLA and partners intend to invest approximately $22.2 million over five years in an RD&E program with the objective of improving phosphorus efficiency in beef, wool and sheepmeat production in southern Australia. The proposed R&D investment has been subjected to an ex-ante (prospective) cost benefit analysis.

The investment criteria produced rely on a set of assumptions about the likely outputs and outcomes of the investment. Given these assumptions, the analysis has indicated that the investment is sound and should provide a positive return.

Executive Summary

Rationale

The application of phosphorus (P) to pastures has remained a key fertiliser practice for southern livestock enterprises for many years. The relative cost of elemental P compared to other farm input costs rose significantly several years ago, but has since fallen back to some extent in the last year or two. Price levels and instability in supply and price may possibly increase in future due to lower grade base materials with higher extraction costs. Inefficient use of P in existing fertiliser P applications is a feature of Australian farming systems due to leaching (losses to groundwater and surface waters) and fixation within the soil.

Being able to increase the utilisation of P already in the soil as well as that applied in fertiliser would reduce the cost of production of Australian beef and sheepmeat by reducing P fertiliser requirements as well as reducing P export off farm.

Objective

The investment in phosphorus R&D by Meat and Livestock Australia (MLA), Australian Wool Innovation (AWI) and others will be targeted at improving phosphorus use efficiency in southern grazing systems.

The Investment

A total investment is assumed of $22.2 million over 5 years (2010/11 dollar terms) and including cash and in-kind from contributing agencies, with approximately $10 million cash or 45% from MLA. The investment is assumed to be made across four themes. The four themes are:

1. Increasing adoption of existing and acceptable phosphorus management practices.
2. Increasing the phosphorus efficiency of existing grazing plants as well as identifying new pasture plants and developing their phosphorus efficiency.
3. Developing new fertiliser types, management systems, and application and timing processes that increase phosphorus availability to plants and increase phosphorus uptake.

4. Presentation of facts about the phosphorus policy environment including peak phosphorus predictions, the phosphorus life cycle, the regulatory environment regarding the impact of phosphorus, and the market environment including claims for the efficacy of other products.

The Analysis

The economic analysis of the investment has been constructed in an expected value framework using probabilities of success due to the large number of uncertainties regarding outputs and outcomes and hence benefits.

Some of the expected outputs (e.g. understanding and knowledge) and outcomes including farm level adoption of eventual products can only be valued in economic terms by making assumptions about the pathway, timing and costs that lead to such adoption. While such analyses are fraught with uncertainty, the assumptions on which the analyses are based have been clearly defined so that debate can focus on the assumptions rather than the results, results being only the logical extensions of the assumptions made.

Results

Given the assumptions made, the results (see table below) indicate that the total program investment should provide positive returns to southern sheep and beef producers. The expected net present value for the total investment (MLA and others) of $19.5 million (present value of costs in 2010/2011 $ terms) is estimated at $77 million over 25 years giving a benefit cost ratio of 4.9 to 1. The probabilistic analysis suggests that the expected investment criteria are likely to remain positive even when a significant range in some key assumptions is taken into account.

Investment Criteria	**Years from year of last investment**					
	0	5	10	15	20	25
Present value of benefits ($m)	6.81	27.32	41.83	58.83	78.60	96.54
Present value of costs ($m)	19.54	19.54	19.54	19.54	19.54	19.54
Net present value ($m)	-12.73	7.78	22.29	39.29	59.06	77.00
Benefit cost ratio	0.35	1.40	2.14	3.01	4.02	4.94
Internal rate of return (%)	Negative	16.0	22.4	24.6	25.5	25.8

Benefits

A summary of the benefit types likely to emerge from the investment in the four themes is provided in the following table.

Summary of Principal Benefit Types

Economic	**Environmental**	**Social**
Increased adoption of phosphorus fertiliser best practice resulting in cost reductions while	Reduced phosphorus contamination of	Maintenance of viable grazing

maintaining or increasing production levels Increased productivity of phosphorus fertiliser applications from application of fertiliser quantities, new product types with retention/release characteristics and application timings that are synchronised with pasture growth demand and closer to the economic optimum determined by stocking rate and the individual risk profiles of producers Improvements in the efficiency of uptake and use of phosphorus by existing pasture legumes so reducing phosphorus fertiliser requirements and reducing total farm costs Identification and/or development of new pasture legumes that are more phosphorus efficient than existing legumes	surface water and sediment due to reduced applications and different forms of P fertiliser	systems in southern Australia and rural workforce /population due to a more profitable grazing sector More informed industry, public and governments with improved management and policy frameworks for phosphorus

Conclusions

Based on the assumptions made in the analysis, the estimated investment criteria are positive.

The investment as envisaged represents a balance between some modest but less risky short-term benefits from Theme 1 and some potentially significantly larger but riskier benefits from the strategic Themes 2 and 3. Theme 4 benefits were not valued.

The investment analysis framework developed here could be used by research managers to monitor progress of the program in an investment analysis context as well as to assess extensions and further investment.

CONTENTS

1. Introduction

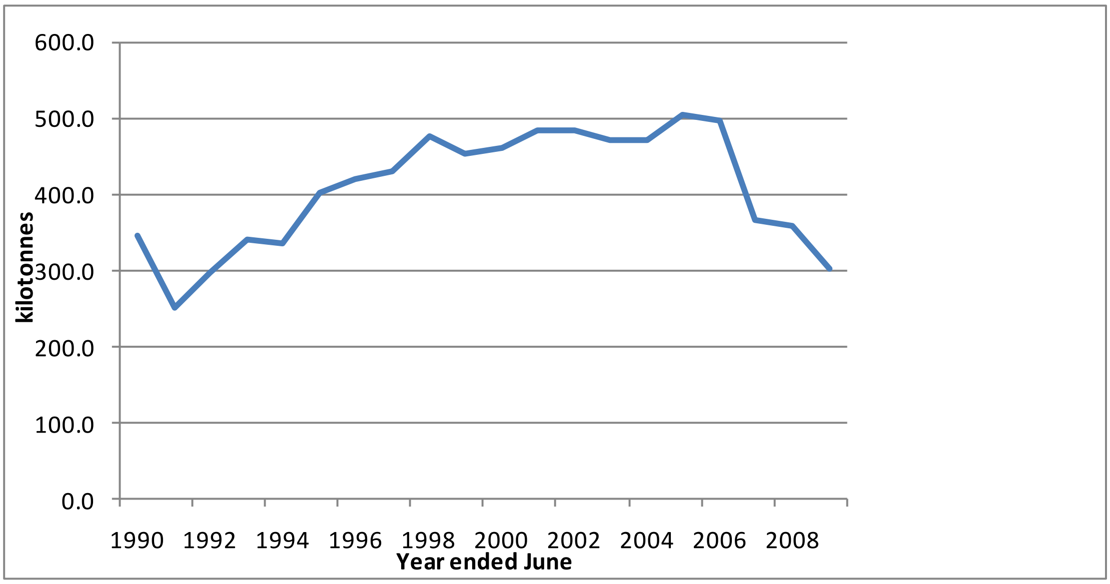
Australian Phosphorus Use

Due to Australia's naturally infertile soils, it is necessary to add extra nutrients to soils in order to lift crop and pasture production. In particular, phosphorus (P) has been the major element added to Australian improved pastures due to the leguminous base of most improved pasture systems in southern Australia.

Levels of phosphorus in some Australian grazing soils have progressively built up over-time because it has been necessary to increase the soil fertility level to increase pasture production. When maintaining higher fertility levels, there continues to be a proportion of the P that is applied that becomes sparingly-available to plants (formally referred to as "fixed P"). For this reason, so that high production can be maintained. in most soils (even with best practice), it is necessary to apply more P than will be exported in products. The amount applied = P exported + P accumulated ("fixed") by the soil. For sheep grazing systems it is typically necessary to apply 5x as much fertiliser P as will be exported in products from the paddock (i.e. 20% efficiency) (Richard Simpson, pers. comm., 2011).

The increase in Australian elemental P consumption in recent decades is shown in Figure 1. The percentage of elemental P tonnage used in southern grazing systems excluding dairying is estimated to be in the order of 35% (mainly single superphosphate), but authoritative estimates are unavailable. The fall in P consumption since 2005 has been largely due to seasonal conditions and fertiliser price increases.

Figure 1: Australian Phosphorus Consumption (Elemental P)

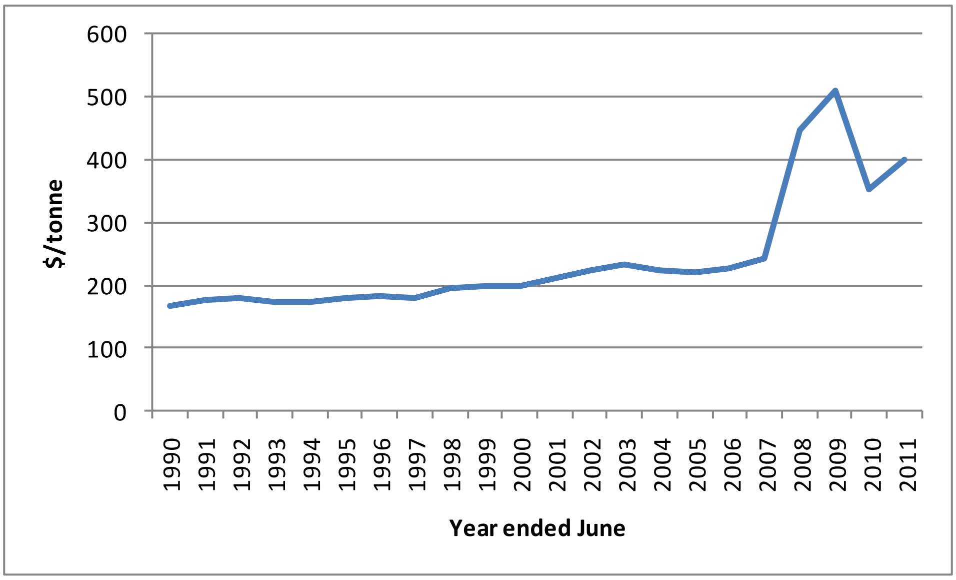


Source: Adapted from ABARES (2010) on the basis of 1 tonne P_2O_5 = 0.4364 tonnes of elemental P

Unit Cost of Phosphorus in Southern Grazing Systems

Recent cost pressures in Australian farming systems have emanated from a number of sources. An increase in the unit cost of P fertiliser due to the past commodity boom is one such source (see Figure 2).

Figure 2: Australian Single Super Price (nominal $)



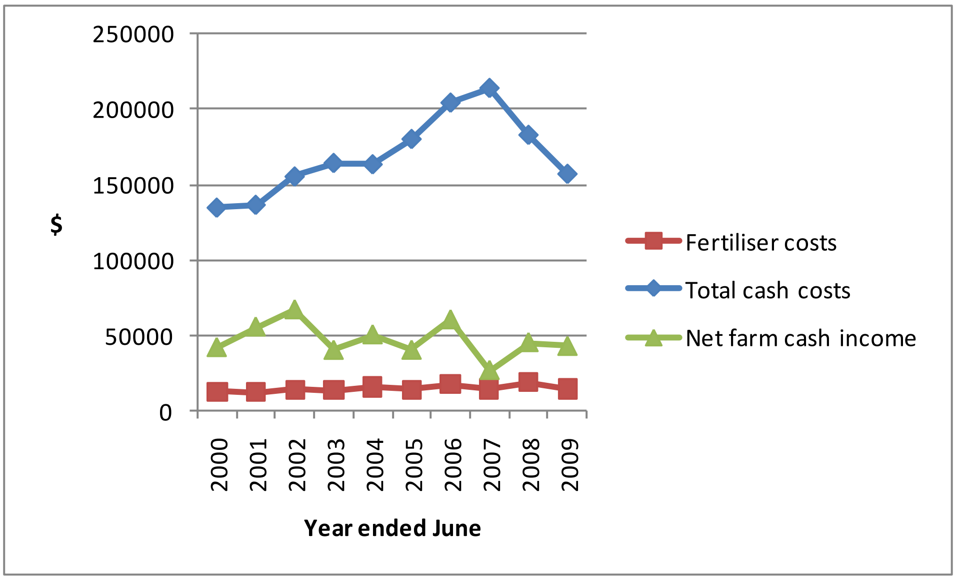
Source: ABARES (2010); 2011 price estimate based on a bulk price delivered Temora NSW, February 2011

Proportion of Total Costs Contributed by Fertiliser

High Rainfall Zone

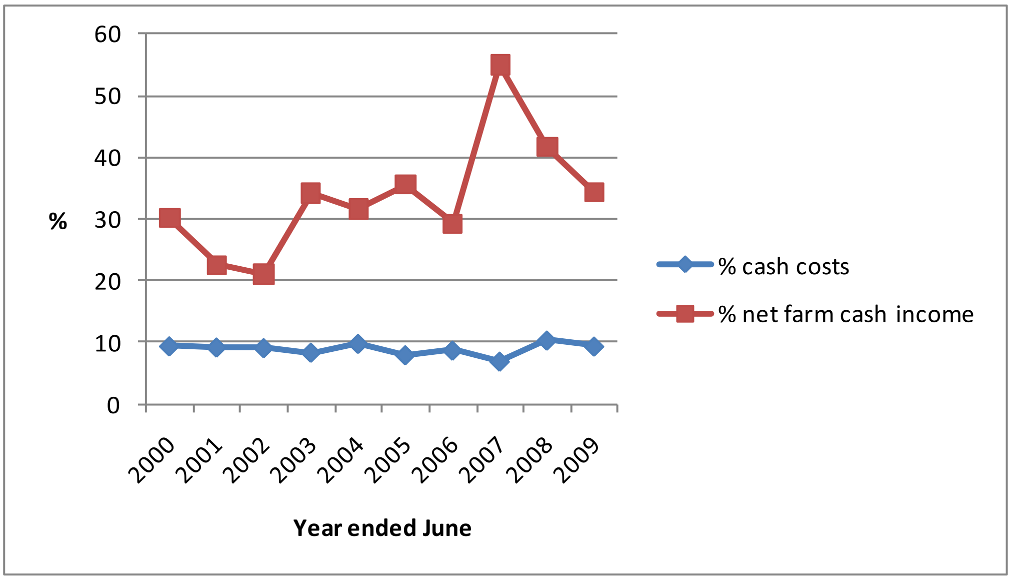
Despite fertiliser price increases in recent years, there has not been much change in the level of fertiliser costs per farm or the proportion of total cash costs contributed by fertiliser purchases in broadacre farms in the High Rainfall Zone (HRZ) (Figures 3 and 4).

Figure 3: Fertiliser Costs, Total Cash Costs and Net Farm Cash Income on HRZ Broadacre Farms (2000 to 2009) (nominal $)



Source: Data from Agsurf, ABARES (2011)

Figure 4: Fertiliser Costs as a Proportion of Total Cash Costs and Net Farm Cash Income on HRZ Broadacre Farms (2000 to 2009)



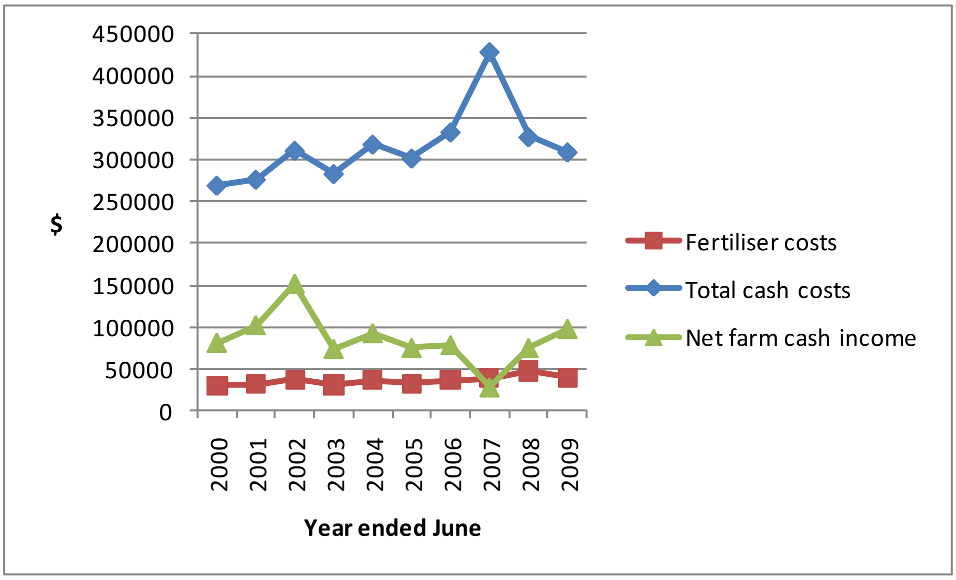
Source: Data from Agsurf, ABARES (2011)

One reason for the reasonably stable fertiliser costs as a proportion of total cash costs is that other farm costs also have risen. It has still been profitable for crop and livestock producers to apply fertiliser as some product prices have also increased, but often at a lower rate than farm input costs. Hence, fertiliser costs as a proportion of net farm cash income have increased in the past ten years.

Wheat Sheep Zone

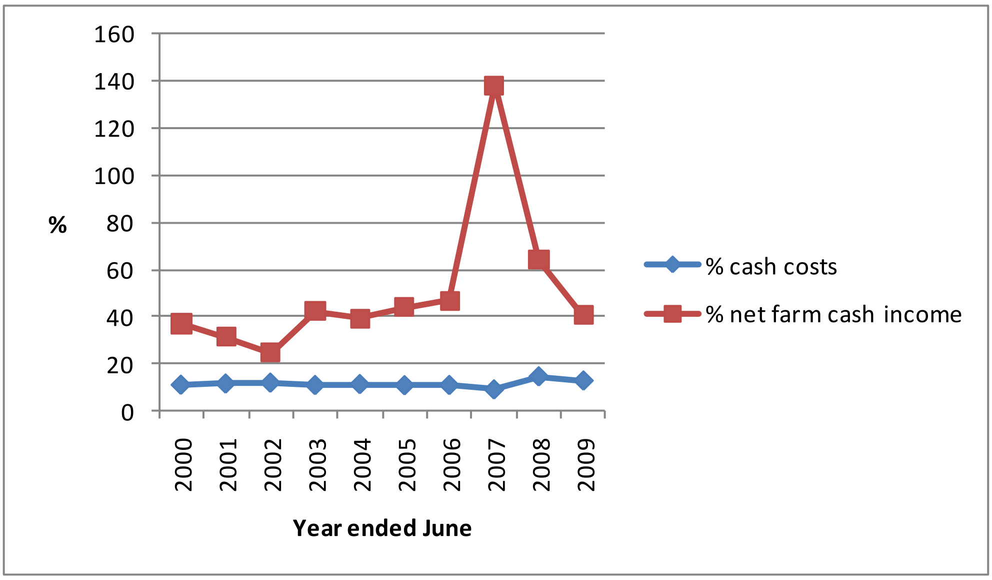
Similar trends are apparent in the Wheat-Sheep Zone (WSZ) to those in the HRZ. However, the level of fertiliser costs is higher per farm than in the HRZ and the proportion of total cash costs is also higher (Figures 5 and 6).

Figure 5: Fertiliser Costs, Total Cash Costs and Net Farm Cash Income on Wheat- Sheep Broadacre Farms (2000 to 2009)



Source: Data from Agsurf, ABARES (2011)

Figure 6: Fertiliser Costs as a Proportion of Total Cash Costs and Net Farm Cash Income on Wheat-Sheep Broadacre Farms (2000 to 2009)



Source: Data from Agsurf, ABARES (2011)

Decadal Change

In the decade to the year 2000, average fertiliser costs as a proportion of total cash costs for HRZ broadacre farms averaged 6.8%; for the immediate past decade this proportion averaged 8.8%.

For WSZ broadacre farms, the average fertiliser costs as a proportion of total cash costs rose to an average of 11.5% in the immediate past decade compared to 9.5% in the previous decade (to the year 2000).

Economics of Fertiliser Use

A summary of several estimates of average return to cost ratio for fertiliser response in grazing systems based on past trial results as of 2001 ranged from 3:1 to 5:1 (Chudleigh and Simpson, 2001). Allowing for a reduced ratio in a commercial application compared to trials, it was concluded that an average ratio of about 3:1 would be typical at the farm level at that time. However, this average estimate did not indicate any information about the marginal return to the last kilogram of fertiliser applied by an individual livestock producer.

A review of the long-term (20 years) phosphate experiment at Hamilton in western Victoria showed that an increase in fertiliser application improved pasture composition, nutritive values and growth, resulting in higher gross margins. The optimal rate under those conditions was 23 kg P per ha at a stocking rate of 18 ewes per ha.

An important message from the Hamilton trials was that to make a profit from the application of fertiliser, the animal production system needed to utilise the additional higher quality pasture grown. This could be achieved by changing the stocking rate, changing from wethers to ewes and other management changes, such as moving to late winter-spring lambing and use of higher producing livestock (Saul et al, 1998). For example, for the typical district stocking rate of 7 ewes per ha and applying 7 to 10 kg P/ha, the gross margin was $120 per ha compared to the gross margin of $250 per ha with 18 kg P/ha and with 18 ewes per ha (Saul et al, undated). Allowing for an annual cost of $40 per ha for additional capital, the gross margin would still increase by $90 per ha. But of course the higher stocking rate could involve greater risk.

Also at each stocking rate in the experiment, the higher gross margin was achieved when 1 kg of P per ha was applied for each ewe/ha (0.7 kg P per DSE). This amount of fertiliser would maintain the soil P status (Agriculture Victoria, 1999).

Producer Segmentation

Information on the different categories of southern livestock producers with regard to their fertiliser applications, attitudes and practices is somewhat limited. An attempt is made here to develop a categorisation that is used in the economic evaluation of the prospective MLA P Program.

Reference is made to the concept of 'critical P' (the soil test level at which pasture growth is near maximum) and targeted use of fertiliser on farms to ensure that soil P fertility and stocking rates are in balance at any soil P fertility level up to and including the critical P level (Simpson et al. 2009; Simpson et al 2010). Hereafter, we refer to this as the "best-practice" P response curve. Farms operating at soil fertility levels in excess of the critical P level (the point where the P-response curve flattens out) do not achieve any further increase in pasture growth and cannot as a consequence carry more stock sustainably.

A. Those who don't apply P at all to their improved pastures. Such producers are not replacing the P exported off the farm each year in animals or animal products. In effect, they are mining the remaining P in the soil and their production systems are not sustainable in the long term. They are not utilising efficiently other farm inputs and the capital invested in their land, pastures and livestock.

B. Those who underfertilise. Such producers do apply some P fertiliser but it may not be every year and on average it is below the replacement levels required. This means that such producers are still mining P from their soils. In the long run, the level of their current production will not be sustainable.

C. Those who overfertilise and exceed the P level suitable for their soil. This group are avoiding P mining as they are building up the soil P bank over and above what is necessary for maximum pasture growth. However, this is a wasteful strategy in both cost terms (higher annual input costs and higher capital investment in their P bank) as well as in terms of additional P loss to the environment.

D. Those who have achieved a balance between soil fertility and stocking rate so that they are operating at levels of pasture production and utilisation that suits their goals and risk attitudes. This may be at any soil fertility level up to and including the critical P level and assumes that soil fertility is managed in such a way that the desired level of soil fertility is maintained by appropriate P fertiliser inputs.

E. Those who are operating with an appropriate balance between soil fertility and stocking rate but who would be more comfortable risk-wise to lower their stocking rate. This means they could lower their P fertiliser inputs, save costs and reduce capital invested in livestock. Profits and risk faced would both decline. Soil P fertility would be allowed to decline to a new level appropriate to the lower stocking rate and would be held there by maintenance of P-fertiliser inputs.

F. Those who are operating with an appropriate balance between soil fertility and stocking rate but who have the capacity to increase their P application and increase their stocking rate provided they are comfortable with the higher stocking rates and potentially increased risk. Hence the group can increase their P fertiliser inputs and raise soil P-fertility up to and including the critical P level as long as they increase their existing pasture utilisation by increasing their stocking rate.

Drivers of the Proposed Investment

In summary the key drivers of the current R&D investment are:

- Inefficient use of existing fertiliser P applications
    - some producers are underfertilising and their P applications are not in balance with their P export in farm products
    - some producers are fertilsing appropriately but P-sorption by Australian soils means that they must apply more P than they will export in products just to maintain their target level of soil-P fertility
    - some producers are overfertilising and reaching and/or maintaining soil P fertility levels in excess of the 'critical P' level appropriate for their soil type, with higher costs than necessary for their level of animal production and with unnecessary P export to the environment
- Other producers may have their soil P fertility level out of balance with their desired stocking rate targets (undergrazers) or have chosen to operate at this position because they are very risk-averse
- Other producers may have their soil P fertility level out of balance with their desired stocking rate targets and operate with a high level of business and environmental risk (overgrazers)
- The bank of sparingly-available P in the soil is very large and if better utilised could help to achieve improved P balance efficiency in grazing systems; this in turn would would reduce P-fertiliser input costs
- There is continuing environmental concern regarding P export with leaching of soluble P (some soils with low P-sorption capacity, e.g. sands) and with P bound to soil particles being washed into waterways (potentially all soils if not managed correctly) and increasing the risk of eutrophication with water quality impacts such as biodiversity loss and increased algal blooms
- Fertiliser P possibly may become higher priced due to future use of lower grade base material and higher extraction costs
- There are potential opportunities to reduce P-input costs for graziers by improving management practices using current knowledge as well as potential for higher P efficiency from improving existing leguminous plants, introducing new plants (e.g Nichols et al, 2007) and developing different forms of P fertiliser and application methods

A major reason why fertiliser decisions on P applications have in some cases diverged from best practice is that producers and advisers do not have high confidence in many of the current tools, for example, the currently used soil tests for P. Also, an improved understanding by producers of the factors regulating supply and utilisation of P in varying soil types and conditions would be beneficial. If this improved understanding is embedded in a profitability context it will allow better predictions of fertiliser requirements and the development of products and management strategies designed to increase P efficiency in Australian pasture systems.

2. Planned Investment

Themes and R&D Areas to be Funded

Funding is proposed in nine principal R&D areas within the four themes of the program as listed in Table 1. Table 2 provides a summary of the objectives of each of the R&D areas.

Table 1: Themes and R&D Areas to be Funded

Theme and R&D Area	Organisational Details
Theme 1: Nutrient Best Practice Management	
1.1 Underfertilising change 1.2 Overfertilising change 1.3 Shift along the best-practice P response curve	Organisation: Tendered Period: July 2011 to June 2016 Principal Investigator:
Theme 2: P Efficient Plants that can Operate in Low P Environments	
2.1. Increasing Existing Legume Phosphorus Efficiency via Breeding	Organisation: Tendered Period: July 2011 to June 2016 Principal Investigator:
2.2 Developing Alternative Leguminous Plants with Greater Phosphorus Efficiency	Organisation: Tendered Period: July 2011 to June 2016

	Principal Investigator:
2.3 Developing Novel Phosphorus-Efficient Leguminous Plants	Organisation: Tendered Period: July 2011 to June 2016 Principal Investigator:
Theme 3: Innovative Fertiliser Technology	
3.1. Developing New Phosphorus Fertiliser Forms to Reduce Leaching	Organisation: Tendered Period: July 2011 to June 2016 Principal Investigator:
3.2. Developing an Anti-P Fixation Product	Organisation: Tendered Period: July 2011 to June 2016 Principal Investigator:
Theme 4: Industry Communication and Policy Development	
4. Policy Aspects of Efficient P Use	Organisation: Tendered Period: July 2011 to June 2016 Principal Investigator:

Table 2: Objectives for the R&D Areas

R&D Area	Summary Objective
1.1 Underfertilising change	To increase the adoption of best management practices by producers not soil testing effectively and not fully utilising currently available knowledge for managing phosphorus in southern grazing systems
1.2 Overfertilising change	
1.3 Shift along the best-practice P response curve	
2.1 Increasing Existing Legume Phosphorus Efficiency via Breeding	To demonstrate that existing keystone legumes used in southern grazing systems can be modified so that they are more phosphorus efficient
2.2 Developing Alternative Leguminous Plants with Greater Phosphorus Efficiency	To identify which new/alternative legume species are more phosphorus efficient than the current keystone species and can be used effectively to reduce P inputs in southern grazing systems
2.3 Developing Novel Phosphorus-Efficient Leguminous Plants	To introduce novel P-efficiency traits into keystone legume species
3.1 Developing New Phosphorus Fertiliser Forms to Reduce Leaching	To develop new phosphorus fertiliser forms and application methods in order to minimise phosphorus leaching from soils
3.2 Developing an anti-P Fixation Product	To develop new phosphorus fertiliser forms and application methods in order to minimise phosphorus fixation in soils
4. Policy Aspects of Efficient P Use	To provide and communicate factual information regarding peak phosphorus, the life cycle of phosphorus use in grazing systems, the environmental impact of phosphorus loss from grazing systems, information concerning phosphorus impacts from new products and regulatory regimes addressing phosphorus use

Investment Inputs

Estimates of the possible Program funding by R&D Area by year are provided in Table 3.

Table 3: MLA Planned Investment by R&D Area for Years ending June 2012 to June 2016
(2010/11 $ million)

R&D Area (abbreviated)	2012	2013	2014	2015	2016	TOTALS
1.1 Underfertilising change 1.2 Overfertilising change 1.3 Shift along P curve	0.5	0.5	0.4	0.4	0.4	2.2
2.1 Improvement to existing plants	0.4	0.4	0.4	0.4	0.4	2.0
2.2 Alternative plants	0.2	02	0.2	0.2	0.2	1.0
2.3 Novel plants	0.2	0.2	0.2	0.2	0.2	1.0
3.1 Reduced leaching product	0.4	0.4	0.4	0.4	0.4	2.0
3.2 Reduced fixation product	0.3	0.3	0.3	0.3	0.3	1.5
4 Policy issues	0.1	0.1	0.1	0	0	0.3
Total	2.1	2.1	2.0	1.9	1.9	10.0

There are also likely to be in-kind contributions from the other contributors and research partners. Table 4 provides estimates of the other investment likely in each of the nine R&D areas for each year and Table 5 provides the combined MLA and partner investment for each year. Partner investments are based on some cash contributions from AWI and most researchers matching in kind resources dollar for dollar with cash resources from MLA.

Table 4: Investment by Others by R&D Area for Years ending June 2012 to June 2016
(2010/11 $ million)

R&D Area (abbreviated)	2012	2013	2014	2015	2016	TOTALS
1.1 Underfertilising change 1.2 Overfertilising change	0.625	0.625	0.5	0.5	0.5	2.75

1.3 Shift along P curve						
2.1 Improvement to existing plants	0.5	0.5	0.5	0.5	0.5	2.50
2.2 Alternative plants	0.25	0.25	0.25	0.25	0.25	1.25
2.3 Novel plants	0.25	0.25	0.25	0.25	0.25	1.25
3.1 Reduced leaching product	0.5	0.5	0.5	0.5	0.5	1.25
3.2 Reduced fixation product	0.375	0.375	0.375	0.375	0.375	1.875
4 Policy issues	0.025	0.025	0.025	0	0	0.075
Totals	2.525	2.525	2.4	2.375	2.375	12.2

Table 5: Investment by MLA and Others in Nine R&D Areas for Years ending June 2012 to June 2016 (2010/11 $ million)

Year	**2012**	**2013**	**2014**	**2015**	**2016**	**TOTALS**
MLA	2.1	2.1	2.0	1.9	1.9	10.0
Others	2.525	2.525	2.4	2.375	2.375	12.2
Totals	4.625	4.625	4.4	4.275	4.275	22.2

3. Expected Outputs

The economic evaluation that follows is embedded in a logical framework of outputs, outcomes and benefits. This framework is based on the proceedings at a workshop held in Febraury 2011 where a principal purpose was the development of a monitoring, evaluation, reporting and improvement (MERI) plan for the envisaged program (Roughley, 2011).

A summary of the expected outputs from each of the nine R&D Areas is provided in Table 6.

Table 6: Summary of Expected Outputs by R&D Area

R&D Area	Expected Outputs
1.1 Underfertilising change	Improved decision making tools, demonstrations, testing kits; and extension material to facilitate adoption of testing and improved fertiliser application levels to maximise profitability and sustainability
1.2 Overfertilising change	
1.3 Shift along P curve	
2.1 Improvement to existing plants	Proof of concept that some existing keystone legumes currently used in southern grazing systems have sufficient variability in phosphorus use efficiency that varieties with higher P efficiency can be produced
2.2 Alternative plants	Proof of concept that some alternative legumes used in southern grazing systems can be managed at lower soil fertility levels and that this reduces the P-costs of the grazing system
2.3 Novel plants	Proof of concept that some keystone legumes of southern grazing systems can be modified to become more phosphate efficient through non-GM or GM technologies so that they can be used successfully in southern grazing systems
3.1 Reduced leaching product	Proof of concept that new fertiliser forms and application processes (e.g. coatings, timing of application) can be developed that reduce losses for leaching in leaky soils used in southern grazing systems
3.2 Reduced fixation product	Proof of concept that new fertiliser forms and application processes (e.g. coatings, timing of applications) can be developed that lower the rate of P fixation in soils of southern grazing systems
4 Policy issues	Peer reviewed information that addresses various issues in the P policy environment including peak phosphorus, the P life cycle, environmental impacts, the credibility of new P products, and regulatory regimes addressing phosphorus use

4. Expected Outcomes

A summary of the expected outcomes from each of the R&D Areas is reported in Table 7.

Table 7: Summary of Expected Outcomes by R&D Area

R&D Area	Expected Outcomes
1.1 Underfertilising change	Increased confidence and adoption of fertiliser testing and use of phosphorus fertiliser application decision aids to increase P use
1.2 Overfertilising change	Increased adoption of lowered fertiliser applications
1.3 Shift along P curve	Increased adoption of fertiliser applications (lower or higher P applications) appropriate for chosen stocking rate levels
2.1 Improvement to existing plants	More P efficient plants sown that reduce annual P fertiliser requirements
2.2 Alternative plants	More P efficient plants sown that reduce annual P fertiliser requirements
2.3 Novel plants	More P efficient plants sown that reduce annual P fertiliser requirements
3.1 Reduced leaching product	A new form of P fertiliser developed and adopted that results in similar animal production levels but for a lower fertiliser P requirement through reduced leaching losses of P on sandy soils
3.2 Reduced fixation product	A new form of P fertiliser developed and adopted that results in less P being incorporated into the soil bank of unavailable P, in turn resulting in more plant available P
4 Policy issues	Facilitation of networking, dialogue and awareness among policy makers, industry, scientists and the community on the implications of and reactions to P scarcity, P export off-farm, promotion of P fertilisers, and constraints to soil testing

5. Expected Benefits

A summary of the principal types of benefits and related costs associated with the expected outcomes of each of the R&D Areas is shown in Table 8.

Table 8: Principal Expected Benefits by R&D Area

R&D Area	Principal Benefits
1.1 Underfertilising change	Increased productivity resulting in increased farm profitability per ha
1.2 Overfertilising change	Reduced fertiliser P cost per ha
1.3 Shift along P curve	Increased farm profitability per ha (shift to the right along the best practice P response curve) or reduced profitability to match desired stocking rate level and risk preference (shift to the left)
2.1 Improvement to existing plants	Reduced fertiliser P cost per ha for the same pasture production level and gross farm income
2.2 Alternative plants	Reduced fertiliser P cost per ha for the same pasture production level and gross farm income
2.3 Novel plants	Reduced fertiliser P cost per ha for the same pasture production level and gross farm income
3.1 Reduced leaching product	Reduced fertiliser P cost per ha for the same pasture production level and gross farm income
3.2 Reduced fixation product	Reduced fertiliser P cost per ha for the same pasture production level and gross farm income
4 Policy issues	Avoidance of unnecessary policy or regulation (peak P or environmental regulation driven) and avoided negative impacts (avoided direct industry costs and removal of constraints to adoption of P testing)

Productivity and Profitability Benefits

Improvements in productivity and profitability are the principal benefits expected from the investment in the program. These benefits are likely to be generated from both increased use of existing practices and from development of new products and practices.

Increased adoption of existing practices by managers may encompass increased extent and frequency of soil P testing, movement of producers to a best practice P production function and increased use of tools for P decision support that may result in fertiliser P savings or increased net income from a higher level of P applied.

Existing pasture legumes may be modified to become more efficient in their fertiliser P use (e.g. roots more easily accessing soil P), so reducing the concentration at which soil P fertility needs to be held, slowing the locking up of P in soils, and thus reducing the amounts of P fertiliser applications and reducing P exported to the environment. This could mean for example producing the same pasture yield as before but with a lower input cost of fertiliser. New forms of fertiliser and modes of application may be developed that may generate increased P use efficiency through lowering P losses via less leaching and by preventing some of the locking up of P fertiliser in both organic and inorganic fractions of the soil.

Environmental Benefits

Reduced P fertiliser application quantities may result in a reduced loss of phosphorus to the environment (e.g. loss of nutrients to deep drainage and contamination of aquifers and surface waters).

Social benefits

Some social spinoffs may be captured from higher profitability in rural areas from the productivity increases. However, of more direct benefit will be the information that better informs policy makers, producers and the public about phosphorus in a wider policy environment. A summary of the benefit types from the four Themes including the nine R&D Areas is provided in Table 9.

Table 9: Summary of Principal Benefit Types

Economic	Environmental	Social
Increased adoption of phosphorus fertiliser best practice resulting in cost reductions while maintaining or increasing production levels Increased productivity of phosphorus fertiliser applications from application of fertiliser quantities, new product types with retention/release characteristics and application timings that are synchronised with pasture growth demand and closer to the	Reduced phosphorus contamination of surface water and sediment due to reduced applications and different forms of P fertiliser	Maintenance of viable grazing systems in southern Australia and rural workforce /population due to a more profitable grazing sector

economic optimum determined by stocking rate and the individual risk profiles of producers Improvements in the efficiency of uptake and use of phosphorus by existing pasture legumes so reducing phosphorus fertiliser requirements and reducing total farm costs Identification and/or development of new pasture legumes that are more phosphorus efficient than existing legumes		More informed industry, public and governments with improved management and policy frameworks for phosphorus

Public versus Private Benefits

The private benefits from these project investments will be captured predominantly by those operating southern grazing systems. The public benefits will be mainly in the form of reduced nutrient contamination of waterways and water storages and an improved national management and policy framework for phosphorus.

Distribution of Benefits Along the Supply Chain

The economic benefits will be captured predominantly by beef and sheepmeat producers. There could be some impacts on fertiliser companies through overall reduced elemental P applications, but potentially positive benefits to the fertiliser industry through the development and supply of new types of fertiliser products. Fertiliser companies may also benefit where soil testing services are expanded or where soil tests could increase fertiliser applications.

Benefits to other Primary Industries

Other cropping industries such as horticulture, grains, sugar, and cotton may benefit from the increased potential to modify plant characteristics with regard to phosphorus use efficiency. This may be so particularly where pastures are used in cropping sequences.

Match with National Priorities

The Australian Government's national and rural R&D priorities are reproduced in Table 10.

Table 10: National and Rural R&D Research Priorities 2007-08

<table>
<tr><th colspan="2">Australian Government</th></tr>
<tr><th>National Research Priorities</th><th>Rural Research Priorities</th></tr>
<tr><td>1. An environmentally sustainable Australia
2. Promoting and maintaining good health
3. Frontier technologies for building and transforming Australian industries
4. Safeguarding Australia</td><td>1. Productivity and adding value
2. Supply chain and markets
3. Natural resource management
4. Climate variability and climate change
5. Biosecurity
Supporting the priorities:
1. Innovation skills
2. Technology</td></tr>
</table>

As a whole, these projects will contribute to National Research Priorities 1 and 3 and Rural Research Priorities 1 and 3, as well as both Supporting Priorities.

6. Pathway to Adoption

The investment in the phosphorus program is planned for five years. There are three distinct groups of projects with clearly different adoption pathways.

First there are applied extension orientated projects (R&D Areas 1.1, 1.2 and 1.3) that aim to shift beef and sheepmeat producers to improved P practices from the viewpoint of increasing profitability and sustainability. The outputs will be improved processes and tools employed by a higher number of producers. Commencement of adoption and the ensuing impact should occur well within the five years of the program duration.

There are already well-developed technical information pathways to communicate phosphorus management information to beef and sheepmeat producers. These include but are not limited to grower groups, fertiliser companies, private consultants, state agency personnel and MLA/AWI. Such groups promote information through various media including personal contact, group meetings and workshops, publications, and the electronic media. The difference that the current investment will make is that specific activities will be targeted to different target markets according to need and known existing constraints to adoption of improved practices.

A need has already been identified to develop a communication plan for the program. The target audience was identified as beef and sheepmeat producers, agribusiness personnel including fertiliser companies, private advisers and consultants, state agency personnel, and those developing and maintaining existing decision aids. The communication plan will specifically take into account the highly influential nature of the relationship between producers and their fertiliser resellers and consultants in making fertiliser decisions.

Secondly, there are project investments (R&D Areas 2.1, 2.2, 2.3, 3.1 and 3.2) that are technical and strategic in nature and where the five year period of investment will deliver only proof of concept of a process or innovation that will eventually improve profitability and sustainability. Assuming the output of one or more 'proofs of concept' is achieved at the end of the five years, a commercialisation period of variable duration would then be necessary before adoption could commence. An exception may occur in the case of Area 2.2 where some earlier adoption may be evident.

The ability to assess the eventual nature and adoption of the end product for most of these R&D areas is important to the cost benefit analysis. Also important are the costs involved in product development and commercialisation from year 5 to adoption of the improved product or process and the number of years it might take from the end of year 5 to the initial adoption. For the purpose of the following analysis, this process is referred to as commercialisation and requires assumptions about time periods, costs and risks for utilising each proof of concept output.

Thirdly, there is a set of projects (R&D Area 4) that is largely policy orientated and which cover the broad phosphorus environment aimed at providing independent and objective information on a range of issues to policy makers including regulators, wool, sheepmeat and beef producers and the fertiliser industry. Publication and promotion of the information assembled by MLA and perhaps other industry groups will be the main pathway to the anticipated change from investment in R&D Area 9 and initial adoption may be relatively rapid.

7. Measurement of Benefits

Baseline

Some data on pasture areas and phosphorus use has been assembled as baseline information in this current analysis. However, industry wide information on phosphorus fertiliser use and practices among different pasture based farming systems was not abundant. An attempt was made to break down the various target markets for the Theme 1 investment but the assumptions that have been made are not held with a high degree of confidence. It is suggested that considerably more baseline information in these areas needs to be assembled at the beginning of the R&D program to improve the targeting and effectiveness of the Theme 1 investments.

Counterfactual

The counterfactual scenario for the analysis is that the intended R&D investment will not take place without the MLA program.

The benefits from Theme 1 investment that are estimated refer to changes that can be attributed to the program. What improvements in fertiliser use that may eventuate without the Theme 1 investment are excluded from the maximum adoption rates (3% to 5%) assumed for each Theme 1 Research Area.

For the other themes where benefits are valued, the potential for other investments producing knowledge and products that may compete with and reduce the value of the benefits attributable to the MLA investment are taken account of in the assumptions on probability of commercialisation.

A key assumption that may affect the return on investment in the program is the future phosphorus price. Much literature abounds on 'peak phosphorus' and a summary is available in Simpson et al (2010). Estimates of the year of peak phosphorus vary considerably. However, it is likely that fluctuations in the price of phosphorus will continue as experienced in the past five years and it is possible that the price of phosphorus in real terms could increase in future.

It should be noted that a definitive prescription of the implications of a price increase for P with and without MLA's prospective P program is complex. Prices for wool, beef and sheepmeat may increase in future due to the potential food crisis. Other farm costs may also increase due to higher energy prices. Relative P price increases are therefore uncertain and no assumptions in this regard have been incorporated in the base analysis. However, the extent to which real price of elemental P may increase in future has been allowed for in the sensitivity analyses. The sensitivity analyses address only first order impacts of real P price changes and do not take into account any ensuing farm management decisions.

Grouping of Projects

The number of projects in the program has not yet been determined. However, for purposes of the cost benefit analysis, it is assumed that all projects will fall into one of the nine R&D Areas identified in Tables 1-7 with the principal benefits from each R&D area identified in Table 8.

Valuation of Benefits by R&D Area

An attempt has been made to value the benefits for only eight of the nine R&D Areas (Themes 1 to 3 only).

While recognised,

- the benefits from avoided costs to industry and government from Theme 4 have not been valued;
- the benefits from any changes that stem from interactions of P with other plant nutrients have not been valued; and
- the reduction in environmental impacts have not been valued.

Furthermore, the benefits from the investments in each of the eight R&D areas have been assumed to be largely independent and additive, although in reality success in one R&D Area may interact with benefits from another R&D Area. An exception therefore allowed for is the pasture rejuvenation/resowing of one improved existing legume species developed from one R&D Area in Theme 2 interacting with a new species being sown that was developed from another R&D Area in Theme 2. On the other hand, different areas of the same farm may accommodate two pasture types and different products may be more suitable for different farms. On balance, a compromise situation was assumed whereby the maximum pasture area for species derived from R&D Areas 2.1, 2.2 and 2.3 could not exceed 90% of the total pasture area.

Target Markets

The target end use market for Themes 1 to 3 of the phosphorus program is wool, sheepmeat and beef producers in the southern grazing region of Australia. The number of farms in the two principal agroecological zones in which the southern grazing region is located is provided in Table 11.

Table 11: Number of Farms and Estimate of Pasture Areas in the Southern Grazing Region

High Rainfall Zone						
State	Farms (no) (a)	Total Area (ha per farm) (a)	Crop Area (ha per farm) (a)	Pasture Area (ha per farm) (b)	Sown Pasture Area (ha per farm) (c)	Total Sown Pasture (ha) (d)
WA	1,741	981	177	804	322	559,906
SA	2,022	1,108	184	924	370	747,331
VIC	6,743	474	88	386	154	1,041,119
NSW	5,924	829	30	799	320	1,893,310
QLD (e)	500	2,327	52	2,275	910	455,000
TAS	1,171	949	58	891	356	417,344
SUBTOTAL	18,101					5,114,011

Wheat –Sheep Zone						
WA	4,910	2,978	1,227	1,751	700	3,438,964
SA	4,005	2,121	795	1,326	530	2,124,252
VIC	5,436	1,108	461	647	259	1,406,837
NSW	11,628	1,766	462	1,304	522	6,065,165
QLD (e)	500	4,415	1,304	3,111	1,244	622,200
SUBTOTAL	26,479					13,657,418
GRAND TOTAL	44,580					18,771,428

(a) Based on the 2008/09 year as derived from AgSurf, ABARES (2011)

(b) By subtracting crop area from total farm area

(c) Estimated by assuming 40% total pasture area is sown pasture

(d) Multiplicand of number of farms and estimated sown pasture area per farm

(e) Estimated

Area of Pasture

The average farm size and the area cropped is reported in Table 11. By subtraction, the area of total pasture is estimated. The pasture area estimated will include both native pasture, degraded pasture and sown pasture.

Area of Sown Pasture

The area of sown pasture is estimated at 40% of total pasture area and this estimate of 18.8 million ha is provided in Table 11.

MLA's Feedbase Investment Plan contains an estimate of sown pasture in 2009 of 15.42 million ha, down from 20.94 million ha in 2001 (Shovelton et al, 2010). Also, the estimated sown area of legumes (subclover, white clover and lucerne) since 2003 was 1.2 million ha per annum (Shovelton et al, 2010, p28). Based on a 20 year pasture renovation cycle, this would give a legume stock of 24 million ha.

The total area of native and self sown pasture estimated in the Feedbase Investment Plan was 16.19 million ha. If 10% of this area is also considered fertilised or open to P fertilisation, the maximum target area for P fertiliser improvement in the following economic analysis is 17.04 million ha. This estimate is supported by the 18.77 million ha estimated in Table 11.

Producer Categorisation

The categorisation of producers attempted earlier (Section 1 and repeated below) grouped producers into the categories in Table 12. The table shows the assumed applicability of Theme 1, 2 and 3 outputs to the different producer categories.

A. Those who don't apply P at all to their improved pastures. Such producers are not replacing the P exported off the farm each year in animals or animal products. In effect, they are mining the remaining P in the soil and their production systems are not sustainable in the long term. They are not utilising efficiently other farm inputs and the capital invested in their land, pastures and livestock.

B. Those who underfertilise. Such producers do apply some P fertiliser but it may not be every year and on average it is below the replacement levels required. This means that such producers are still mining P from their soils. In the long run, the level of their current production will not be sustainable.

C. Those who overfertilise and exceed the P level suitable for their soil. This group are avoiding P mining as they are building up the soil P bank over and above what is necessary for maximum pasture growth. However, this is a wasteful strategy in both cost terms (higher annual input costs and higher capital investment in their P bank) as well as in terms of additional P loss to the environment.

D. Those who have achieved a balance between soil fertility and stocking rate so that they are operating at levels of pasture production and utilisation that suits their goals and risk attitudes. This may be at any soil fertility level up to and including the critical P level and assumes that soil fertility is managed in such a way that the desired level of soil fertility is maintained by appropriate P fertiliser inputs.

E. Those who are operating with an appropriate balance between soil fertility and stocking rate but who would be more comfortable risk-wise to lower their stocking rate. This means they could lower their P fertiliser inputs, save costs and reduce capital invested in livestock. Profits and risk faced would both decline. Soil P fertility would be allowed to decline to a new level appropriate to the lower stocking rate and would be held there by maintenance of P-fertiliser inputs.

F. Those who are operating with an appropriate balance between soil fertility and stocking rate but who have the capacity to increase their P application and increase their stocking rate provided they are comfortable with the higher stocking rates and potentially increased risk. Hence the group can increase their P fertiliser inputs and raise soil P-fertility up to and including the critical P level as long as they increase their existing pasture utilisation by increasing their stocking rate.

Table 12: Target Market Producer Categories

Category	**Estimate of total area (%)**	**Estimate of Current P Usage (kg per ha per annum)**	**Applicability of Themes**	**Pasture area (million ha) (a)**	**Total Current P usage (tonnes)**
A	30	0	None	5.1	0
B	30	7	1,2,3	5.1	35,700
C	10	14	1,2,3	1.7	23,800
D	10	9	2,3	1.7	15,300
E	5	10	1,2,3	0.85	8,500
F	15	7	1.2,3	2.55	17,850

Total	100			17.0	101,150

Source: Agtrans Research after some input from Phil Graham and Richard Simpson

(a) Based on 17 million ha multiplied by % total area

The non-applicability of any of the theme outputs to Producer Group A is assumed due to the difficulty of achieving any change. It is assumed that this group use zero or very little P fertiliser and are not likely to be enticed to change management practices.

The total P use derived in Table 12 is very much an approximate synthesised estimate based on a set of uncertain pasture areas, estimated proportions of different categories of producers and their estimated P application rates. However, the resulting 101,000 tonnes of elemental P estimated can be compared with the elemental P consumption that can be attributed to southern grazing industries (Table 13). The 101,000 tonnes estimated is surprisingly close to the estimate of 104,000 tonnes estimated for total P fertiliser consumption by southern grazing industries, but this similarity may have been coincidental.

Table 13: Elemental P Consumption

Total P_2O_5 Fertiliser Consumption in 2009 (tonnes)	Elemental P consumption (x by 0.43) (tonnes)	Proportion grazing (excluding dairy and any P consumed by northern grazing systems)	Estimate for southern broadacre grazing (tonnes)
693,800 (a)	298,334	35% (b)	104,417

(a) ABARES (2010)

(b) Source: Simpson et al (2010), p 10, provides an estimate of 40% of total P applied to all pastures. This 40% may include dairy pasture and would include any elemental P consumed by grazing industries in northern Australia; hence a slightly lower proportion is used.

Applicability of Outcomes/Benefits to Different Target Markets

Table 14 sets out the assumed applicability of the benefit from each R&D Area to the various target markets.

Table 14: Applicability of R&D Area Outcomes to Target Markets

Theme and R&D Area	**A**	**B**	**C**	**D**	**E**	**F**
Theme 1						
1.1 Underfertilising change						
1.2 Overfertilising change						
1.3 Shift along P curve					qualitative benefit	

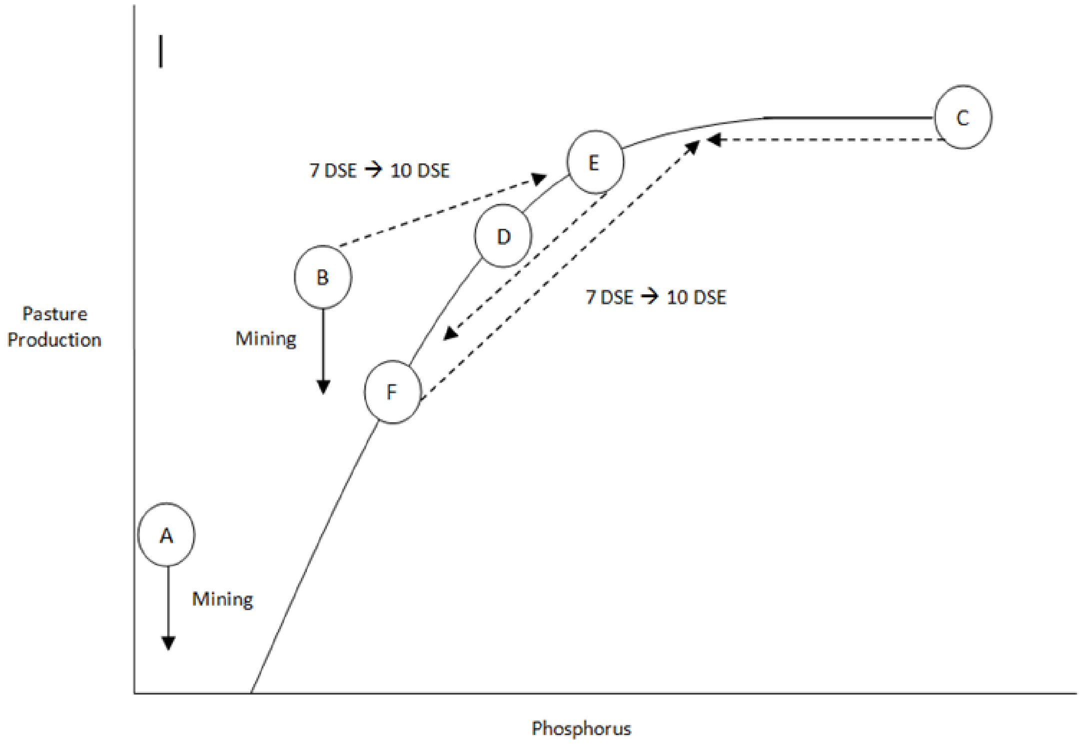
Theme 2						
2.1 Improvement to existing plants						
2.2 Alternative plants						
2.3 Novel plants						
Theme 3						
3.1 Leaching reduction		15% of total pasture area				
3.2 Fixation reduction						

Valuation of Benefits

The most common benefit valued for most of the R&D Areas (1.2, 2.1, 2.2, 2.3, 3.1 and 3.2) is the reduced application of fertiliser P per ha (Table 8). However, increased profitability may also arise from increased P application and an increase in stocking rate by some producers resulting in higher net returns per unit area (R&D Areas 1.1 and 1.3).

A diagrammatic representation of the position of the various producer categories in relation to the best practice P curve is provided in Figure 7.

Figure 7: Diagrammatic Representation of Producer Categories in Relation to Best Practice P Curve



An estimate of the most likely level of final benefit that is expected to be delivered from the eight R&D Areas where benefits are valued is provided in Table 15.

Table 15: Expected Level of Final Benefit by R&D Area

R&D Area	Most likely level of net benefit captured	Added Gross Revenue	Additional Costs	Source
1.1 Underfertilising change	$12.6 per ha per annum	Change from 7 DSE to 10 DSE at $22 per DSE gross margin = $66 per ha	1.5 kg P per DSE at $4.54 per kg ($6.81 per DSE) plus annualised added livestock capital for 3 DSEs at $8 per DSE plus additional annual labour and infrastructure costs of $3 per DSE=$53.4 per ha	Table 12; Agtrans Research for additional cost assumptions; NSW DPI Average Gross Margins for 10 sheep enterprises (a)

1.2 Overfertilising change	$18.2 per ha per annum	Saving of 4 kg P per ha at $4.54 per kg =$18.2 per ha	Nil	Table 12
1.3 Shift along P curve	$22.1 per ha per annum	Change from 7 DSE to 10 DSE at $22 per DSE gross margin = $66 per ha	0.8 kg P per DSE at $4.54 per kg ($3.63 per DSE) plus annualised added livestock capital for 3 DSEs at $8 per DSE plus additional annual labour and infrastructure costs of $3 per DSE=$43.9 per ha	Table 12, Agtrans Research for additional cost assumptions; NSW DPI Average Gross Margins for 10 sheep enterprises (a)
2.1 Improvement to existing	30% fertiliser P saving per annum	Saving of 30% of existing P usage at $4.54 per kg	Nil (b)	Simpson et al (2010)
2.2 Alternative plants	30% fertiliser P saving per annum	Saving of 30% of existing P usage at $4.54 per kg	Nil (b)	Simpson et al (2010)
2.3 Novel plants	30% fertiliser P saving per annum	Saving of 30% of existing P usage at $4.54 per kg	Nil (b)	Based on potential savings for existing and alternative plants
3.1 Leaching reduction	30% less leaching and hence fertiliser saving	Saving of 30% of existing P usage at $4.54 per kg on 15% of pasture soils across different producer categories	Nil (b)	P Workshop assumption (that a saving equivalent to that calculated for improved plants will be possible)
3.2 Fixation reduction	30% fertiliser P saving per annum	Saving of 30% of existing P usage at $4.54 per kg	Nil (b)	P Workshop assumption (that a saving equivalent to that calculated for improved plants will be possible)

(a)These gross margins were based on prices for September to February 2009/2010; product prices have increased since then and gross margins are now considerably higher (Phil Graham, pers.comm., 2011).

(b) Commercialisation costs included elsewhere (see next section). Some recovery of commercialisation costs may affect the distribution of benefits between input suppliers and producers, but as these benefits may accrue largely to Australian companies, the benefits to Australia as estimated are assumed to remain the same.

Cost and Timing of Commercialisation

Assumptions for the cost and time for commercialisation are provided in Table 16.

Table 16: Cost and Time for Commercialisation

R&D Area	**Commercialisation Time (years)**	**Commercialisation Cost ($ million per annum)**
1.1 Underfertilising change	0	0
1.2 Overfertilising change	0	0
1.3 Shift along P curve	0	0
2.1 Improvement to existing plants	10	$0.3 pa for 10 years
2.2 Alternative plants	0	0
2.3 Novel plants	12	$0.3 pa for 12 years
3.1 Leaching reduction	5	$0.2 pa for 5 years
3.2 Fixation reduction	10	$0.3 pa for 10 years

Risk Assessment

The probabilities assumed in the analysis for successful outputs and successful commercialisation are presented in Table 17.

Table 17: Probability of Successful Outputs and Commercialisation by R&D Area

R&D Area	Most likely probability of a successful output (%)	Most likely probability of successful commercial-isation (%)
1.1 Underfertilising change	80	not applicable
1.2 Overfertilising change	80	not applicable
1.3 Shift along P curve	80	not applicable
2.1 Improvement to existing plants	30	80
2.2 Alternative plants	80	not applicable
2.3 Novel plants	20	40
3.1 Leaching reduction	40	60
3.2 Fixation reduction	20	40

Level and Timing of Adoption

Table 18 provides assumptions used for the level and timing of adoption. Theme 2 adoption relies on the re-sowing of pastures with new or changed plant species. The decision to replant with a more productive pasture species is difficult (Leech et al, 2009) and will depend on the increased productivity expected and the cost of replanting. Currently there is a very low rate of pasture renewal, that is, less than 2.5% of pasture each year (Shovelton et al, 2010, p 28). The assumption used here is that the plants with improved phosphorus use efficiency will be adopted in preference to other species but the maximum level of adoption still will take 20 years to reach after commercial seed becomes available.

The maximum adoption levels in Table 18 for Theme 1 products may appear low. However, much of the easy fruit may have been already been picked as significant extension programs have been evident in most states in past years (e.g. Triple P Program). Moreover, the adoption levels assumed in Theme 1 results in a total of 980 producers changing practices and realising the stated benefits. This probably means that in the order of 2,000 to 3,000 producers may need to be involved in the Theme 1 program in some way over the five year period, depending on the conversion rate from involvement to benefit capture.

Table 18: Levels and Timing of Adoption

R&D Area	Applicability (Producer Category)	Year adoption commences	Years of maximum adoption reached	Level of maximum adoption (% target audience) (a)
1.1 Underfertilising change	B	Year 3	Years 7-9	3
1.2 Overfertilising change	C	Year 3	Years 7-9	5
1.3 Shift along P curve	(left to right only) F	Year 3	Years 7-9	4
2.1 Improvement to existing plants	B,C,D,E F	Year 16	Year 36	40
2.2 Alternative plants	B,C,D,E,F	Year 5	Year 25	3
2.3 Novel plants	B,C,D,E,F	Year 18	Year 38	40
3.1 Leaching reduction (b)	15% of B,C,D,E,F	Year 11	Year 15	50
3.2 Fixation reduction	B,C,D,E,F	Year 16	Year 20	50

(a) Translated to pasture areas as contained in Table 12

(b) Including coastal WA, and SE SA

For benefits 1.1, 1.2 and 1.3 the benefits are assumed to commence in year 3, reach a maximum in year 7, are held at the maximum for three years and then gradually decline to zero over the next ten years. This latter assumption is based on no allowance being made for any continuing extension after the end of the investment and a continuing turnover of farm managers.

Current and Future Values of Elemental P

Elemental P values have been based on the current single superphosphate bulk price of $400 per tonne (excluding GST) landed on farm. Assuming 8.8% elemental P contained in one tonne of superphosphate (Incitec Pivot, 2003), the elemental P value would be $4.54 per kg. Sensitivity analyses on the P value were carried out to assess the direct impact of future real increases in the price of P. The current base (2010/2011) price has been assumed to increase in real terms by 0, 1, 2.5, and 5% per annum.

No account has been taken of second order effects in this analysis (e.g. how producers respond to an increase in real P prices in terms of level of P use, input mix, or enterprise mix). Such second order effects will depend on the prices of other inputs and the prices received for farm products.

Summary of Assumptions

The foregoing sections have described the many assumptions that have been made in this economic evaluation. A summary of the key assumptions is shown in Table 19.

Table 19: Summary of Key Assumptions in the Economic Analysis

Category	Biophysical Assumptions	Total Potential Area[1]	Year of First Adoption[2], Years of Maximum Adoption, Maximum Adoption Level (%)	On-Farm Budget Implications	Probability of successful Research Output/ Commercialisation
Theme 1: Nutrient Best Practice Management					
1.1 Under fertilising	Under fertilising by 30% (3kg P/ha). Increase P application to lift stocking rate 3 DSE/ha extra with 1.5 kg per DSE or 4.5 kgP/ha applied	5.1 mill ha	yr3, yrs 7-9, 3% *Benefits fall to zero after 10 years*	Costs: 4.5 kg P x $4.54/kg P[3] ($20.43 per ha)+ livestock, infrastructure and labour /ha for 3 DSE = $33/ha Income: 3 DSE/ha extra x $22/DSE = $66/ha. Net: $13/ha benefit	80% / na
1.2 Over fertilising	Over fertilising (on the flat part of the best practice P curve) by 4kg P/ha). Reduce fertiliser input/cost maintain output. Savings are 4kgP/ha while maintaining stocking rate	1.7mill ha	yr3, yrs7-9, 5% *Benefits fall to zero after 10 years*	$4.54/kg P x 4kg = $18/ha	80% / na
1.3 Shift along P curve	On the best practice P curve but can increase stocking rate from 7 DSE/ha to 10 DSE/ha by applying 0.8 kg P per DSE	2.5 mill ha	yr3, yrs7-9, 4% *Benefits fall to zero after 10 years*	Costs: 2.4 Kg P x $4.54/kg P per ha ($10.90 per ha) + livestock, infrastructure and labour /ha for 3 DSE = $33/ha Income: 3 DSE/ha extra x $22/DSE = $66/ha	80% / na

				Net: $22/ha benefit	
Theme 2: P Efficient Plants in Low P Environments					
2.1 Improve existing plants	↓P requirements of current southern pasture plants (legumes) through selection → 30% reduction in current P use	11.9 mill ha (after subtracting Cat A area)	yr16, yr36, 40%	Approx $4.54/kg P x 2.55kg=$12/ha	30% / 80%
2.2 Alternative plants	↓P requirements of alternative legumes used in southern grazing systems by managing them at lower soil fertility levels	11.9 mill ha (after subtracting Cat A area)	yr5, yr25, 3%	Approx $4.54/kg P x 2.55kg=$12/ha	80% / na
2.3 Novel Plants	↓P requirements of keystone legumes through GM and non-GM methods	11.9 mill ha (after subtracting Cat A area)	yr18, yr38, 40%	Approx $4.54/kg P x 2.55kg=$12/ha	20% / 40%
Theme 3: Innovative Fertiliser Technology					
3.1 Reduced leaching P Fertiliser	↓P fertiliser requirements on high leaching soils through improved fertiliser related technologies → 30% reduction in current P use (high leaching soils (parts of WA, Tas and SE Aust) for 15% of total pasture area.	1.8 mill ha (15% of 11.9 mill ha, after subtracting Cat A area)	yr11, yr 15, 50%	Approx $4.54/kg P x 2.55kg=$12/ha	40% / 60%
3.2 Reduced Fixation P Fertiliser	↓P fertiliser requirements on high fixing soils through improved fertiliser related technologies → 30% reduction in current P use	11.9 mill ha (after subtracting Cat A area)	yr 16, yr 20,50%	Approx. $4.54/kg P x 2.55kg=$12/ha	20% / 40%
Theme 4: Industry Communication and Policy Development					

4. Policy Issues	Not evaluated in economic terms	na	na	na	Na

[1]High Rainfall Zone (4.6 million ha), Wheat Sheep Zone (12.4 million ha). Represents maximum target area for P fertiliser improvement of 17 million ha

[2]Years from first year of investment

[3] P costs based on an average cost of single super landed on farm of $400/t and 8.8% elemental P

8. Results for Deterministic Analysis

All costs and benefits were expressed in 2010/11 dollar terms. All costs and benefits were discounted to 2010/11 using a discount rate of 7%. The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for many of the estimates. Benefits were estimated for the length of the investment period plus a maximum of 25 years from the last year of investment (2015/16) to the final year of benefits assumed (2040/41).

Investment criteria were estimated for both total investment and for the MLA investment alone. Each set of investment criteria were estimated for different periods of benefits, with the benefit period commencing with the last year of investment as year 0. The investment criteria, based on the most likely assumptions, are reported in Tables 20 and 21.

Table 20: Investment Criteria for Total Investment for Each Benefit Period

(discount rate 7%)

Criterion	**0 Years**	**5 years**	**10 Years**	**15 years**	**20 years**	**25 years**
Present value of benefits ($m)	6.81	27.32	41.83	58.83	78.60	96.54
Present value of costs ($m)	19.54	19.54	19.54	19.54	19.54	19.54
Net present value ($m)	-12.73	7.78	22.29	39.29	59.06	77.00
Benefit cost ratio	0.35	1.40	2.14	3.01	4.02	4.94
Internal rate of return (%)	Negative	16.0	22.4	24.6	25.5	25.8

Table 21: Investment Criteria for MLA Investment for Each Benefit Period

(discount rate 7%)

Criterion	**0 years**	**5 years**	**10 years**	**15 years**	**20 years**	**25 Years**
Present value of benefits ($m)	3.07	12.31	18.84	26.50	35.41	43.49
Present value of costs ($m)	8.81	8.81	8.81	8.81	8.81	8.81
Net present value ($m)	-5.74	3.50	10.03	17.69	26.60	34.68
Benefit cost ratio	0.35	1.40	2.14	3.01	4.02	4.94
Internal rate of return (%)	negative	16.0	22.4	24.5	25.4	25.7

The proportions of total benefits (proportion of total present value of benefits or PVB) from each of the three themes analysed and for each R&D area are provided in Table 22.

Table 22: Source of Benefits

Theme and R&D Area	Estimate of PVB ($ m)	Proportion of total PVB (%)
R&D Area 1.1	14.43	15.0
R&D Area 1.2	6.47	6.7
R&D Area 1.3	17.66	18.3
Total Theme 1	38.56	40.0
R&D Area 2.1	14.50	15.0
R&D Area 2.2	13.78	14.3
R&D Area 2.3	3.22	3.3
Total Theme 2	31.51	32.6
R&D Area 3.1	11.55	12.0
R&D Area 3.2	14.92	15.4
Total Theme 3	26.47	27.4
Total	96.54	100

If the probability of success of each project group was assumed to be 100%, the hypothetical proportion of benefits from each of the seven R&D Areas is provided in Table 23.

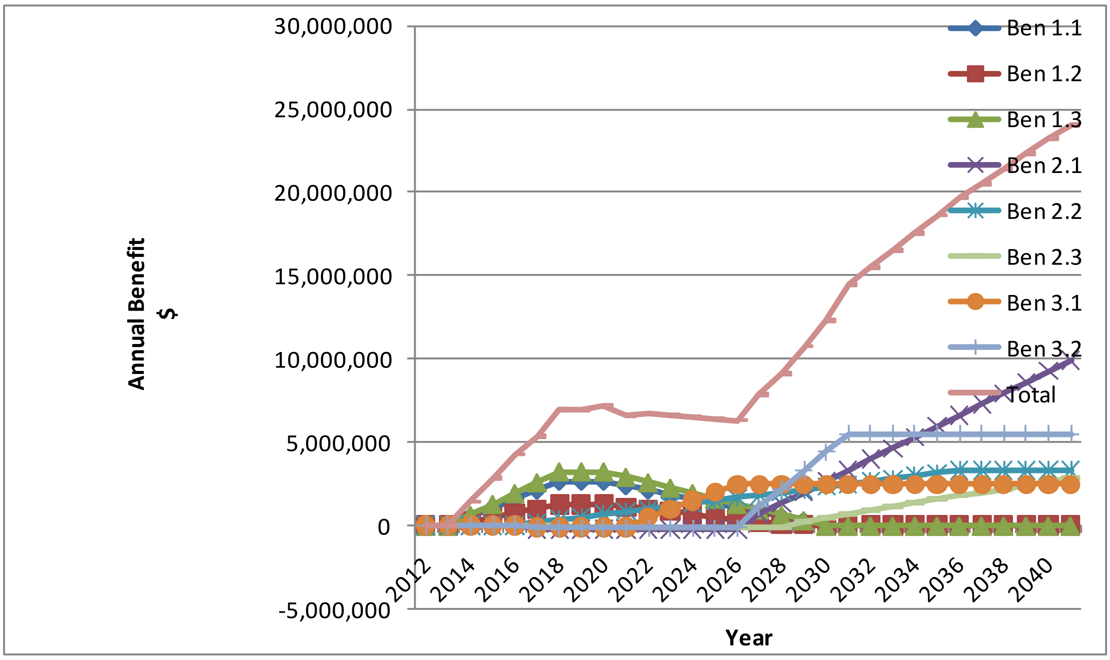
Table 23: Source of Benefits by R&D Area Given 100% Probability of Success of Outputs and Commercialisation

Theme and R&D Area	**Estimate of PVB ($ m)**	**Proportion of total PVB (%)**
R&D Area 1.1	18.04	4.3
R&D Area 1.2	8.09	1.9
R&D Area 1.3	22.08	5.2
Total Theme 1	48.21	11.5
R&D Area 2.1	64.17	15.3
R&D Area 2.2	17.23	4.1
R&D Area 2.3	45.90	10.9
Total Theme 2	127.30	30.3
R&D Area 3.1	49.07	11.7
R&D Area 3.2	195.73	46.6
Total Theme 3	244.81	58.2
Total	420.32	100.0

Theme 3 and particularly R&D Area 3.2 (fixation reduction) now appears to be the major source of benefits in this risk free scenario, with Theme 3 rising from 27% of the expected total PVB to 58%. The relative contribution from Theme 1 investment falls (40% down to 11%) when risk is ignored. This change in benefit proportions illustrates the importance of recognising an appropriate balance between the risk–reward attributes of different investment types.

The cash flow of expected benefits by R&D Area is shown in Figure 8 for the total investment in the program.

Figure 8: Annual Benefit Cash Flow



Sensitivity Analyses

Sensitivity analyses were carried out on several variables and results are reported in Tables 24 to 26. All sensitivity analyses were performed on the total investment using a 7% discount rate with benefits taken over the life of the investment plus 25 years from the year of last investment. All other parameters were held at their base values (the most likely estimate).

Table 24 shows the investment criteria for the total investment at different discount rates.

Table 24: Sensitivity to Discount Rate

(Total investment, 25 years)

Criterion	Discount Rate			
	0%	5%	7%	10%
Present value of benefits (m$)	327.99	132.09	96.54	28.60
Present value of costs (m$)	22.20	20.23	19.54	8.39
Net present value (m$)	305.79	111.86	77.00	20.22
Benefit cost ratio	14.77	6.53	4.94	3.41

Table 25 shows the sensitivity of the investment criteria to an increase in the real price of P over the benefit periods. A more thorough analysis could take into account second order impacts such as the fertiliser application response to the P price. This response will be determined largely by relative product prices and profitability of marginal P applications. However, due to time and resource constraints for the analysis, product prices and other input prices were held constant. Demand may fall in the short term with an increase in the P price but in the longer term falls may be less severe. Given the static analysis here, the results do reflect an increased direct benefit to the investment as the P price increases, for Areas 1.2, and Themes 2 and 3 (the 30% saving in P costs). However, any secondary management changes (e.g. decreases in P application rates with associated changes in stocking rates) have not been accounted for in the static analysis. On the other hand, the level of adoption of successful P saving technologies contained in Themes 2 and 3 could be enhanced via an increase in the P price.

Given the above, the results show that the investment criteria are moderately sensitive to the assumed P increase. At a 5% per annum increase in P price, the benefit cost ratio more than doubles.

Table 25: Sensitivity to Price of Elemental P

(Total investment, 7% discount rate, 25 years)

Criterion	**Annual Increase in P Price**			
	Base 0% pa	1% pa	2.5% pa	5% pa
Present value of benefits (m$)	96.54	111.38	141.14	220.37
Present value of costs (m$)	19.54	19.54	19.54	19.54
Net present value (m$)	77.00	91.84	121.60	200.83
Benefit cost ratio	4.94	5.70	7.22	11.28
Internal rate of return (%)	25.8	26.4	27.3	29.1

Table 26 shows the sensitivity of the investment criteria to the level of maximum adoption assumed for each R&D Area.

Table 26: Sensitivity to Maximum Adoption Rates

(Total investment, 7% discount rate, 25 years)

Criterion	**Level of Maximum Adoption**		
	50% Base	Base	150% Base
Present value of benefits (m$)	47.16	96.54	195.31
Present value of costs (m$)	19.54	19.54	19.54
Net present value (m$)	27.26	77.00	175.77
Benefit cost ratio	2.41	4.94	9.99
Internal rate of return (%)	15.0	25.8	43.9

9. Stochastic Analysis

A secondary analysis was undertaken using Monte Carlo simulation. The key assumptions of the probability of success of outputs and commercialisation, and the maximum level of adoption were deemed to be key drivers of the rate of return to the program investment and were treated stochastically. The assumptions on benefits was likely to be correlated with adoption so were treated deterministically in the analysis. Probability functions for the three variables were expressed as the minimum, the most likely, and the maximum (triangular distributions). The distributions used are provided in Table 27 and it was assumed that the values of these variables were independent of one another.

Table 27: Probability Distributions for Variables Used in Stochastic Analysis

(minimum, most likely, maximum)

R&D Area	Probability of Successful Output	Probability of Commercialisation Given a Successful Output (%)	Level of Maximum Adoption
1.1 Underfertilising change	70, 80, 90	100,100,100, 10000,	1,3,6
1.2 Overfertilising change	70, 80, 90	100, 100, 100	1,5,10
1.3 Shift along critical P curve	70, 80, 90	100, 100, 100	1,4,8
2.1 Improving existing plants	10, 30, 60	10, 80, 100	20, 40, 60
2.2 Alternative plants	40, 80, 90	100, 100, 100	1, 3, 6
2.3 Novel plants	0, 20, 50	10, 40, 60	20, 40, 60
3.1 Leaching reduction	20, 40, 60	10, 60, 80	20, 50, 80
3.2 Fixation reduction	0, 20, 50	10, 40, 60	20, 50, 80

The simulation used the distributions to generate probability density functions of two investment criteria (net present value and benefit cost ratio). These investment criteria distributions are shown in Figures 9 and 10. Figure 9 shows the distribution of the net present value for all investment. From the simulation run made, the results showed that the net present value is most likely to lie in the range of $52 million to $107 million. Figure 10 indicates the benefit cost ratio is likely to range between 3.7 to 1 and 6.4 to 1.

Figure 9: Distribution of Net Present Value

(Total investment, discount rate 7%, 25 years)

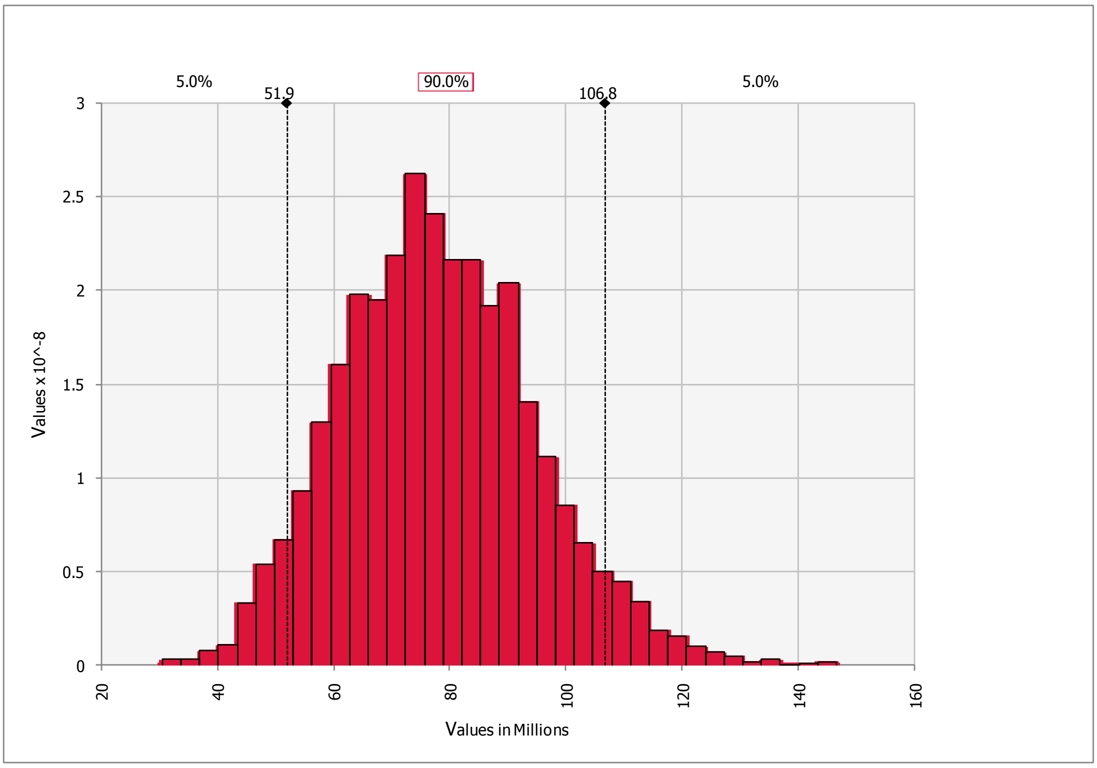
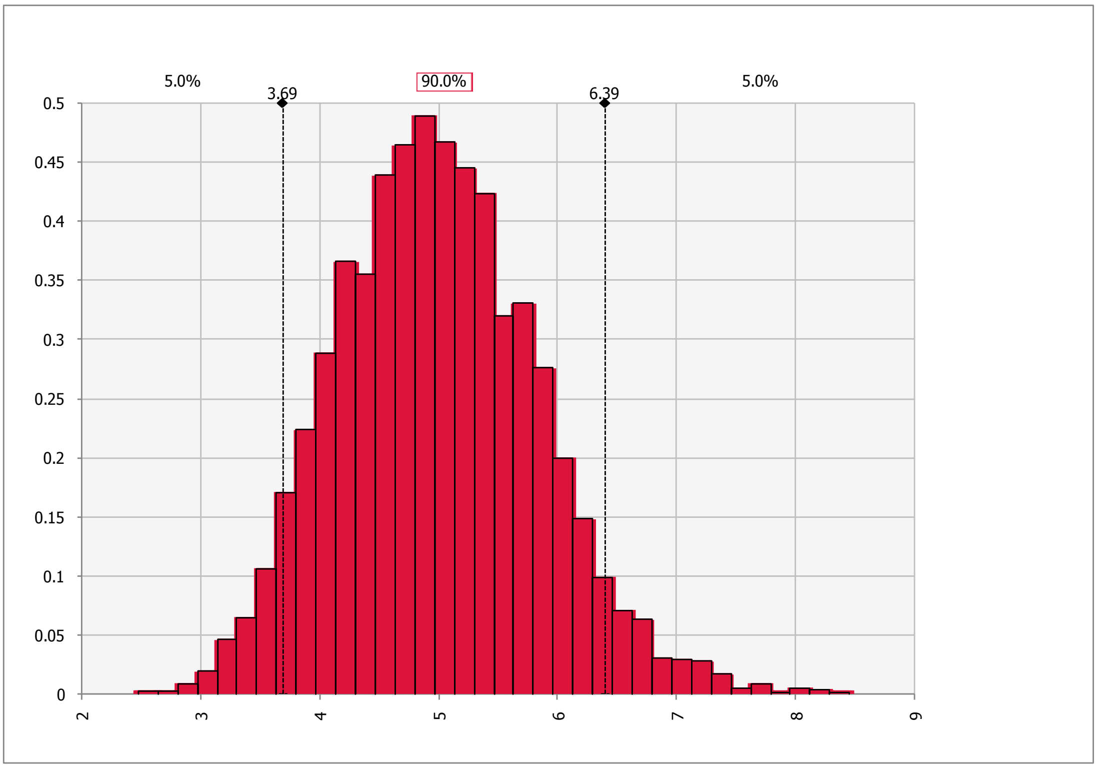


Figure 10: Distribution of Benefit Cost Ratio
(Total investment, discount rate 7%, 25 years)



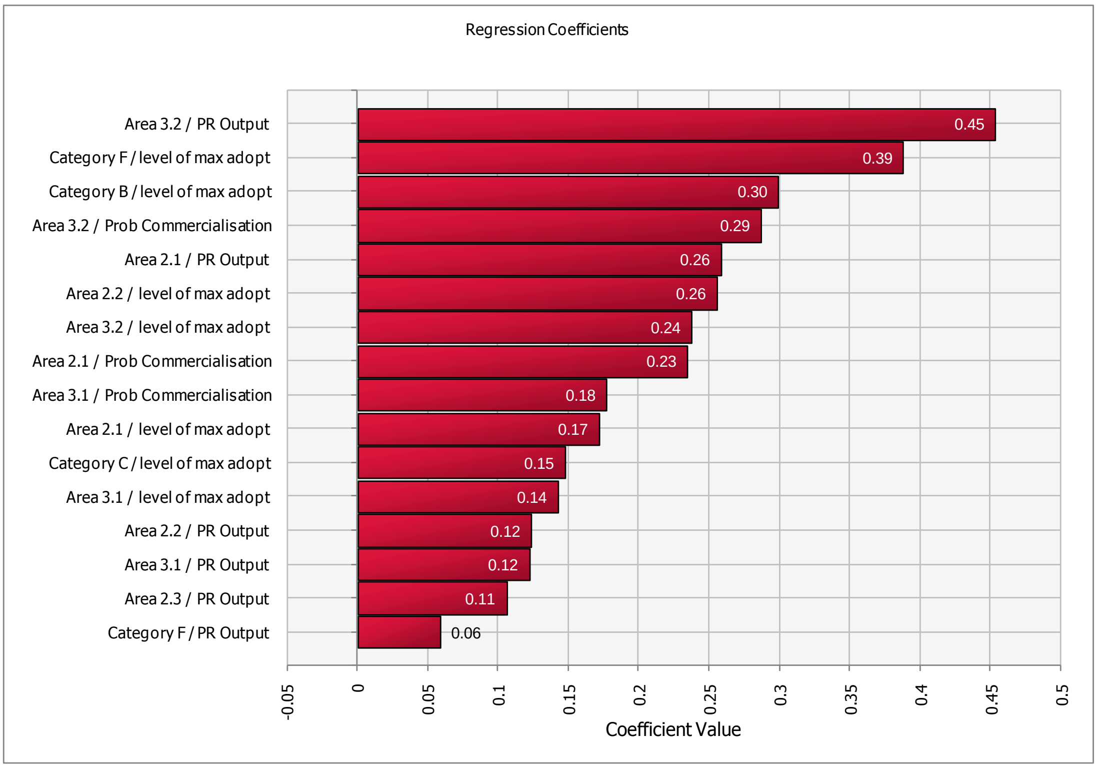
The distribution for the present value of benefits (PVB) for specific R&D Areas is shown in Appendix 1.

Tornado Diagram

Figure 11 shows the individual input variables treated stochastically that are the most influential in driving the net present value of the investment. The output probability and the probability of commercialisation for the P fixation reduction product were both important drivers of the NPV (first and fourth in importance). The level of maximum adoption for Category F producers (those currently on the best practice P curve but who could increase pasture production and utilisation was the second most important driver. It should be noted that only three variables (probability of outputs, probability of commercialisation, and the level of maximum adoption) were included in the stochastic analysis.

Figure 11: Tornado Diagram for Net Present Value

(Total investment, 7% discount rate, regression coefficients)



10. Confidence Rating

The results produced are highly dependent on the assumptions made, many of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 28). The rating categories used are High, Medium and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some significant uncertainties in the assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in the assumptions made

Table 28: Confidence in Analysis of Phosphorus R&D Program Investment

Coverage of Benefits	Confidence in Assumptions
High	Medium

11. Conclusions

This ex-ante analysis has first attempted to summarise the expected activities, outputs, outcomes and benefits in a qualitative descriptive manner from all R&D Areas to be funded within the four themes.

The attempt to value the expected benefits has required exploration of logical pathways from expected outputs to eventual benefit capture. These pathways as defined may be questionable and improved; furthermore, it is accepted that some research outcomes often are not planned and are serendipitous.

As the analysis was ex-ante, it required assumptions of significant uncertainty based on little data and expectations only. Despite expectations, some projects may not be successful in delivering benefits and other projects may surprise.

Given the assumptions made, the results indicate that the total program investment should provide positive returns to southern sheep and beef producers. The expected net present value for the total investment (MLA and others) of $19.5 million (present value of costs in 2010/2011 $ terms) is estimated at $77 million over 25 years giving a benefit cost ratio of 4.9 to 1.

The probabilistic analysis suggests that the expected investment criteria are likely to remain positive even when a significant range in some key assumptions is taken into account.

The investment as envisaged represents a balance between some modest but less risky short-term benefits from Theme 1 and some potentially significantly larger but riskier benefits from the strategic Themes 2 and 3.

The approach (or some modification to it) could be used by the program management to monitor the program and its progress and possibly to provide information for assessment of extensions and further investment. Measuring the adoption of program outputs and products and how they are used in farm decision making and/or further research will be important features of monitoring and reporting.

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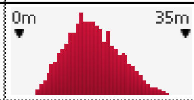
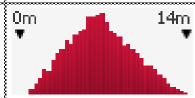
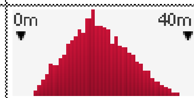
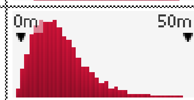
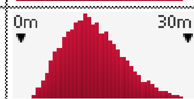
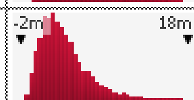
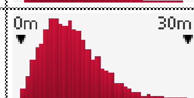
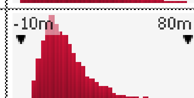
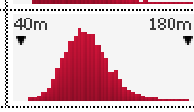
Appendix 1: Distribution of PVBs for all Sources of Benefits

Name	Graph	Min	Mean	Max
Area 1.1 / Total PVB		4,722,482	16,038,800	30,894,920
Area 1.2 / Total PVB		1,374,269	6,902,717	13,774,290
Area 1.3 / Total PVB		4,631,985	19,131,340	37,087,310
Area 2.1 / Total PVB		875,196	12,871,340	47,304,910
Area 2.2 / Total PVB		3,279,061	13,400,600	28,559,070
Area 2.3 / Total PVB		-634,891	3,555,977	16,942,930
Area 3.1 / Total PVB		1,397,188	9,625,029	29,194,890
Area 3.2 / Total PVB		-358,175	16,053,020	79,862,640
Total / Total PVB		52,241,040	97,578,820	177,623,100