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Review of MLA Pasture Evaluation and Improvement Investment for the Lamb, Sheepmeat and Beef Industries

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Acronyms and Abbreviations

ABARE	Australian Bureau of Agricultural and Resource Economics
ACIAR	Australian Centre for International Agricultural Research
AFFA	Agriculture, Fisheries and Forestry - Australia
Ag WA	Agriculture Western Australia
APPEC	Australian Pasture Plant Evaluation Committee
ARGT	Annual Ryegrass Toxicity
ARRIP	Australian Rural Research in Progress
AWI	Australian Wool Innovation
C	Crop specialists
CCN	Cereal cyst nematodes
CLIMA	Centre for Legumes in Mediterranean Agriculture
CRC	Co-operative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DM	Dry matter
DNRE	Department of Natural Resources and Environment
DPIF	Department of Primary Industry and Forestry
DRDC	Dairy Research and Development Corporation
DSE	Dry sheep equivalents
DSS	Decision Support System
GM	Genetically Modified
GMO	Genetically Modified Organisms
GRDC	Grains Research and Development Corporation
HRZ	High Rainfall Zone
IGER	Institute of Grassland and Environmental Research
IP	Intellectual Property
LC	Mixed Livestock and Crop Enterprises
LIGULE	Low Input Grasses Useful in Limiting Environments
LWA	Land and Water Australia
MAS	Marker Assisted Selection
MLA	Meat and Livestock Australia
MRC	Meat Research Corporation
NAPLIP	National Annual Pasture Legume Improvement Program
NLIGN	Native and Low Input Grasses Network
NPICC	National Pasture Improvement Co-ordinating Committee
NSW Ag	New South Wales Agriculture
PHI	Pioneer Hi-Bred International
PIC	Pasture Improvement Committee
PIRD	Producer Initiated Research and Development
PVI	Pastoral and Veterinary Institute
PVR	Plant Variety Rights
R & D	Research and Development
RDC	Research and Development Corporation
R, D, & E	Research, Development and Extension
RIRDC	Rural Industries Research and Development Corporation
SARDI	South Australian Research and Development Institute
SCA	Standing Committee on Agriculture
SGGS	Sustainable Grain and Grazing Systems
SGS	Sustainable Grazing Systems
SIAA	Seed Industry Association of Australia
SR	Stocking rate
TIAR	Tasmanian Institute of Agricultural Research
TPSKP	Temperate Pastures Sustainability Key Program

UNE	University of New England
WSZ	Wheat Sheep Zone
WUE	Water Use Efficiency

Executive Summary

Early in 2002, MLA commissioned „a review of pasture evaluation and improvement for the lamb and sheepmeat industry" [subsequently expanded to include the southern beef industry]. The objectives were to: -

1. Review previous MLA and MRC investments in pasture plant improvement and evaluation and identify the impact for sheepmeat, lamb and beef producers

2. Identify opportunities for pasture improvement considering the individual lamb, sheepmeat and beef businesses needs, community and industry needs and the technologies that are now available

    a. It is expected that the current rates of genetic gain for production and disease resistance traits in pasture plants by conventional breeding and biotechnology processes will be identified

    b. It is also expected that the potential for biotechnology to improve the rate of genetic gain will be identified

3. Identify the current capacity in Australia and overseas to undertake pasture improvement work

4. Suggest an investment strategy for MLA: -

    [a] linking pasture plant improvement with other activities in pasture improvement, and

    [b] after assessing constraints and opportunities, indicate key steps to enable the above investment strategy for R & D findings in pasture improvement to be implemented with maximum benefit to the red meat industries.

A brief review of the red meat industries, showing trends since 1990, was followed by an evaluation of previous MLA/MRC investments in pasture plant improvement. It was concluded that: -

- Within the limits of the information available, MLA investments have generally been appropriate. Most projects have achieved their objectives. Some have been particularly successful, especially the DNRE perennial grasses and SARDI lucerne improvement programs, each of which has produced a stream of new cultivars which have been received favorably by the wider industry. A number of other projects, whilst producing valuable information, have not met their objectives fully; they include the projects on biotechnology, the native grass *Microlaena*, and toxicity screening of phalaris
- MLA-supported projects are not well geared to provide reliable information on outcomes and industry impacts. A number of recommendations have been made to improve the monitoring of the projects and evaluate their outcomes and impacts. The proposals cover: the form of project reports to MLA; project reviews; provision and on-line storage of project summaries, including objectives, outputs, outcomes and industry impacts. [See consolidated list of Recommendations at end of Executive Summary].

An assessment of the impact of pasture plant improvement was then sought from a wider group of red meat industry stakeholders - producers, extension workers, consultants, administrators, researchers, R & D Corporations and seed industry executives - in order to: -

- consider how well R & D in pasture plant improvement had met the needs not only of red meat producers but also the wider community and industry (Objective 1)
- provide a general appreciation of the past, current and future „landscapes" for pasture improvement, and
- provide a platform for considering specific opportunities for further pasture improvement (Objective 2).

Some 100 people from all southern states of Australia and from NZ were interviewed or sent written responses to questionnaires developed for specific stakeholder groups. It was found that: -

- While most red meat industries in southern Australia are in either the HRZ or the WSZ, significant numbers of sheep and cattle are also found in two other distinctive areas, namely the NW Slopes and Plains of NSW and the Mallee regions of SA and Victoria

- The vast majority of the animal output is produced on high input pastures, though recently, coinciding with an increasing focus on conservation issues, there has been some mild interest, especially in the HRZ, in low input systems based on native grasses

- During the past decade, the availability of new pasture plants [especially legumes], has been an important factor in raising pasture productivity in the WSZ. Most such plants have been cultivars of subterranean clover, annual medics and lucerne. However, the first releases of an array of annual legumes, now being selected for the pasture phase of the rotation, are beginning to have an impact, with one plant, pink serradella, cv Cadiz, being sown on 300,000 ha in 2001

- In contrast, since 1990, new pasture plants have had less impact on red meat production in much of the HRZ. There, management, reflected in continuing use of superphosphate, with strategic dressings of lime in southern NSW, together with moderate to high stocking rates, has been the key factor in determining pasture output

- Negative farmer attitudes to pastures and a limited extension network are major factors in the low levels of animal production which generally characterise the NW Slopes and the Mallee regions.

Prior to responding specifically to Objective 2, it was necessary to research background information on:

[i] factors affecting pasture output in southern Australia, where it was found that : -

- Improved plants, pasture management, systems studies and the transfer of research findings all have an important role in improving pasture productivity. Whilst the initial increases in pasture output are normally the result of introducing new plants, appropriate fertiliser and grazing policies are then needed to produce and utilise the herbage produced

- Since 1990, major improvements in animal output and farm income from improved pastures in southern Australia have flowed from systems studies and the transfer of research findings, in which researchers, extension workers, consultants and producers have all played a part. Notable research/extension projects that have catalysed changes in management practice in the past decade, e.g. PROGRAZE and The Grassland"s Productivity Program, have been briefly summarised.

[ii] the changing scene for pasture plant improvement since 1990 :

- Major changes have occurred in pasture plant improvement since 1990, particularly in the level of public funding. While delivery of improved pasture plants was once accepted as a public responsibility, the development of commercially viable improvement programs now lies increasingly in the private sector

- Reduced public investment in pasture plant improvement, though considerable overall, has occurred unevenly. In NZ, all pasture plant breeding is now undertaken in the private sector, whilst in Victoria, a decision was recently made to withdraw public funding from most conventional breeding; varying levels of public investment still occur in the other Australian states.

- Profound changes in the seed industry, with major Australian companies now owned by overseas interests and thus part of the global market for the production and sale of pasture seeds, have had major effects on the breeding and sales of improved pasture cultivars

- Activities of selected R & D Corporations have been described briefly, and their procedures for investing in and monitoring of, projects and their use of project outcomes outlined. These procedures are particularly effective in GRDC. Both GRDC and DRDC have developed longstanding and successful relationships with

- The industries they serve. A brief analysis is made of the Corporations" experience in, and management of, IP

- Organisational structures for the delivery of improved cultivars, including the roles of the public and private sectors and the R & D Corporations, have been briefly discussed

- The importance of continuing and viable public plant breeding is argued, not only to increase production, but also to maintain long term stability of pastures and combat environmental problems.

[*iii*] *a comparison of conventional pasture plant breeding and biotechnology :*

- Genetic gains from conventional breeding on a range of herbage species have been recorded for a number of plant traits and indices of animal production. DM gains have ranged between 0.18% and 2.83% per annum, with yearly gains of NZ bred cultivars of white clover on grazed plots averaging more than 2.5% since 1985. Annual liveweight gains of lambs have varied between 0.33% and 1.37%

- One-off gains of transgenic plants can only be estimated as no GM cultivars of pasture plants are yet available commercially. Such estimates range from a 10% to 30% increase in DM production. Problems of realising gains from genetically modified plants are canvassed.

- Seed industry attitudes to transgenics are described briefly. Other uses of biotechnology in plant improvement, especially gene sequencing and marker assisted selection, are discussed

- The complementary roles of biotechnology and conventional breeding in pasture plant improvement to achieve maximum improved performance are described and their inter-relationship stressed. Biotechnology provides a number of extra tools to help the breeder who is essential for the development of new cultivars.

- The response to Objective 2 can be summarised thus: -

- Considerable opportunities exist for improving and sustaining pasture productivity in southern Australia. They include the provision of better plants, improving the evaluation of new cultivars, raising the level of pasture management, developing optimal managements to improve sustainability and reduce environmental degradation, and improving decision-making

- Particular opportunities include: the selection of improved plants for the WSZ, parts f the HRZ and low input environments; developing an improved protocol for

- Cultivar evaluation; developing agronomic packages for new species; weed control; collection of information from long lived pasture; and, increasing extension activities to hasten transfer of R & D findings

- It is not recommend that MLA invest in all these opportunities. Support appears appropriate in projects in the following areas: selecting perennials for productivity and sustainability in the WSZ; selecting grasses for low input environments; developing improved cultivars of perennial pasture plants, using both conventional breeding and biotechnology; assisting in the development of agronomic packages for new species; sustainability and reduced environmental degradation; and extension of research findings to producers of red meat

- The R & D opportunities listed have not all been accorded equal priority. The reasoning used, together with recommendations on specific projects for possible investment, is pursued further in responding to Objective 4.

A number of R & D investment opportunities in the area of pasture plant improvement were analysed using the MLA scoring model.

- The opportunities selected for analysis included two specific proposals and three hypothetical opportunities, two in conventional breeding and one in biotechnology. The key assumptions made for each of these opportunities were documented by the evaluation team.

- The scoring model was found to be an effective tool in assessing project proposals and other ideas for R&D investment. The scoring component appears particularly useful in assembling scores from different personnel in making overall subjective assessments. However, the second component, the calculation of investment criteria, was found to be somewhat inflexible and not particularly suitable for assessing pasture plant improvement investments. A critique of the MLA scoring model is presented in Appendix 5. The development of documentation including a users manual for the model is highly recommended, if it is to be cost-effective to use, externally or in house.

- A summary of the scores and investment criteria for all five opportunities is presented. Care should be taken in comparing and interpreting results, particularly the investment analysis results, since they are highly dependent on the specific assumptions made and how well benefits are represented in the model. Further, in many respects, the opportunities specified were illustrative rather than specific, well-constructed proposals. The results from the analyses are therefore indicative rather than constituting a definitive comparative analysis of the best opportunities.

The response to Project Objective 3 on R & D capacity can be summarised thus: -

- In a number of advanced countries, including Australia, responsibility for undertaking work in pasture improvement is being assumed increasingly by the private sector, a development associated with reduced public investment

- Multinational companies have become predominant in pasture plant improvement. National, regional or local private companies and consultancies now provide services covering a range of key areas in pasture improvement

- We strongly believe that Australia should retain sufficient capacity to undertake the range of work needed for pasture improvement. The only proviso to this principle is that there should be no unnecessary duplication of work in Australia and NZ. The present capacity in the public and private sectors in Australia is generally sufficient to satisfy the requirements for most work needed on the key areas in pasture improvement, including sufficient expertise to cover MLA"s interests in biotechnology.

- Some of the R & D required will only be done in the public sector. We have concerns for the continuing viability of public pasture plant breeding and for scientific, economic and social research. Unless there is public investment in such activities, they will become constraints to resolving problems and achieving targets.

Our response to Objective 4 can be summarised thus: -

- A précis of our perception of the role of MLA is followed by some explanation of the criteria used selecting a number of opportunities recommended for MLA investment in pasture improvement. These include projects in extension, plant selection for difficult environments, cultivar improvement, sustainability, weed control, modelling and funding of post-graduate scholarships

- Proposals are included for continuing investment in plant improvement within a broad portfolio of projects, which we are confident will provide major benefits for the red meat industries in short and longer term

- Extension activities and problems associated with salinity stand out as the highest opportunities for new MLA investment

- Suggestions are made for a split in funding between plant improvement and other activities in pasture improvement, and between conventional breeding and biotechnology

- A section on the possible role of MLA in different scenarios is followed by some proposals we believe are needed to properly develop and implement an investment strategy for MLA. They include recommendations to obtain a national perspective for R, D and E in pasture improvement and for continuing input from producers.

- Guidelines are included for choosing projects in which to invest and suggestions made for obtaining advice in selecting such projects. Some discussion is included on joint funding of projects in the public and private sectors, and the importance of more uniform project monitoring and evaluation and the value of wider dissemination of project outcomes and impacts stressed.

RECOMMENDATIONS [numbered as in the report]

Recommendations on internal MLA management [pp 18 - 19 of report]

We recommend: -

1. A common method of presentation of milestone and final reports in which the project objectives, outputs and, where appropriate, outcomes and any industry impacts are clearly shown

2. Summaries should be made of projects already completed, with particular emphasis on output and outcomes/expected outcomes. This would not only facilitate the MLA reporting process, but would also provide a framework for further monitoring of adoption [early stage outcomes] after projects are completed. Such a structured summary could be made a mandatory part of final milestone reports

3. Summary information on projects [agreed objectives, outputs and any outcomes and industry impacts] be included in a computer data base for online access. The existence of the projects should already be recorded on ARRIP

4. A benefit: cost analysis be undertaken on a sample of recently completed projects to monitor and evaluate outcomes and impacts over a time period and results included in the data base. Such analyses should be undertaken on all future projects

5. Independent reviews of large projects - including benefit: cost analysis if appropriate - when the level of investment exceeds $500 000 or after 5 years.

Recommendations for MLA promotion [p 31 in report]

6. MLA should take such measures as are necessary to demonstrate to its stakeholders, especially red meat producers, the contribution it has made, and continues to make, to improving pasture productivity.

7. MLA should promote the existence of its Donor Company and the opportunities it provides to assist funding for plant improvement

Recommended criteria to determine MLA's investment strategy [pp 88 and 104-105 in report]

8. The primary objective of MLA"s investment strategy - to maximise benefits to the red meat industry, in short and long term - requires support of both work designed to reduce constraints to productivity and that which addresses environmental issues

9. Projects supported should be compatible with the objectives and priorities of the R & D programs adopted by MLA for the red meat industries

10. MLA should continue to invest selectively in plant improvement as part of a portfolio of support for R, D & E covering major constraints to pasture improvement. Work designed to unlock the constraints that restrict the use of improved cultivars developed in the MLA projects and prevent the realisation of their potential should also be supported

11. Total funds available for investment in pasture improvement be divided in proportions of some 35% for projects covering the selection and breeding of improved pasture plants and 65% for projects on other key activities in pasture improvement. We also propose that a maximum of 40% of funds available for pasture plant improvement be allocated to biotechnology

12. MLA should not be the sole funder of major and continuing programs. The main focus of its investment should be in specific short-term projects with clearly defined objectives, sometimes as part of a long-term investigation funded by other bodies

13. A committee [with representatives of government, RDCs and agribusiness] be established to determine national priorities for R, D and E and assign broad responsibilities to participating groups to undertake and fund the necessary investigations

14. Collaboration should be sought with other bodies to develop proposals for investment in work with common interests. MLA should be proactive if necessary in promoting investment opportunities, using the Company"s commitment as leverage in seeking funds from other potential funders

Recommended criteria for choice of investment projects [pp 102 and 105 in report]

15. Proposals should be clearly focused, with objectives achievable within an agreed time frame, and score well in a benefit:cost analysis

16. Projects likely to have the biggest impact on the red meat industries be given high priority, especially if it is perceived to have positive effects on more than one of the „Triple Bottom Line" outcomes

17. Projects of national significance be given some positive weighting

18. An advisory committee should be set up by MLA to assist in determining specific projects for investment and advising on research providers

19. Wherever possible, MLA should support people who have an established record [but note recommendations on post-graduate scholarships]

20. An indication should be given that for long term investment projects support will be provided for an agreed time frame greater than the normal period of support subject to satisfactory progress being made and milestones being met

Other Recommendations [pp 46-47 and 62 in the report]

21. MLA should consider whether to make decisions on IP policy, managing IP, cultivar development and commercialisation independent of other RDCs, or attempt to develop agreed principles and mechanisms with other Corporations

22. MLA should take the initiative to facilitate discussions between the public sector and SIAA to develop an improved protocol for cultivar evaluation and make a modest investment towards the establishment of any such agreed protocol

Scope of Review

Early in 2002, Meat and Livestock Australia [MLA] commissioned „a review of pasture evaluation and improvement investment for the lamb and sheepmeat industry". The background to the review was the investment that MLA and the previous Meat Research Corporation [MRC] had made over the previous 15 years in a range of R&D activities in pasture breeding, evaluation and management. The initial terms of reference for the review referred to a number of perennial grasses, including native grasses, and legumes that had been released as a result of these activities. Reference also was made to the changing commercial environment as a consequence of plant breeders rights, the development of national breeding programs to co-ordinate and facilitate pasture breeding programs conducted by the public sector, and the increasing role of biotechnology in plant breeding. A further consideration was the impact at the producer level of R&D investment into pasture plant improvement, compared with investment into other constraints in the production and marketing of red meat.

At the time the consultants were appointed, the review was extended in scope to include „Southern Beef Production", thereby encompassing the actual and potential impact of pasture plant improvement on the red meat industries in southern Australia. Subsequently, further adjustments were made to the objectives of the review to ensure a broad consideration of research, development and adoption, including the steps that might be necessary to implement the findings in pasture improvement with maximum benefit to the red meat industries. The Terms of Reference [prior to its implied extension to include the beef industry], including some background information relevant to the conduct of the review, is included as Appendix 1.

Objectives

The objectives of the review, undertaken in two stages, were :-

Stage 1

1. Review previous MLA and MRC investments in pasture plant improvement and evaluation and identify the impact for sheepmeat, lamb and beef producers

2. Identify opportunities for pasture improvement considering the individual lamb, sheepmeat and beef businesses needs, community and industry needs and the technologies that are now available

   a. It is expected that the current rates of genetic gain for production and disease resistance traits in pasture plants by conventional breeding and biotechnology processes will be identified

b. It is also expected that the potential for biotechnology to improve the rate of genetic gain will be identified

Stage 2

3. Identify the current capacity in Australia and overseas to undertake pasture improvement work

4. Suggest an investment strategy for MLA : -

   [a] linking pasture plant improvement with other activities in pasture improvement, and

   [b] after assessing constraints and opportunities, indicate key steps to enable the above investment strategy for R & D findings in pasture improvement to be implemented with maximum benefit to the red meat industries.

Summary of review process

In this paper, the review is outlined and the findings reported. The first step in the process was an evaluation of previous MLA/MRC investments in pasture plant improvement in terms of their outputs and outcomes. Then, a survey of researchers, advisers, farmers and graziers, R & D Corporations and seed company executives was undertaken in order to :

[i] evaluate achievements from plant selection and breeding,
[ii] identify constraints to the national pasture feed-base, including those resulting from other key factors as well as pasture plants and,
[iii] develop a platform from which to consider opportunities for future investments in pasture improvement. In the second stage of the review, the current capacity for R&D in pasture plant improvement was identified, and the MLA scoring and investment model tested, using examples of investment opportunities. Finally, an investment strategy was developed, and a pathway outlined to enhance the productivity, sustainability and profitability of red meat production on farms around Australia.

Industry Overview

During the 1990s, important trends occurred in the Australian red meat industries, trends that have implications for pasture plant improvement and pasture management. The main trends are detailed below.

Sheepmeat and beef - production and export

Despite a massive reduction in sheep numbers (from 173m in 1990 to 118m in 2000), the production and gross value of lamb increased from around 250,000 t and $365m (1990) to 370,000 t and $668m (2000). This increase in value was predominantly due to the export performance of lamb, which increased from 43,000 t (value $113m) in 1990 to 112,000 t (value $447m) in 2000. Over the same period, mutton production declined but mutton exports rose modestly (from 150,000 t to 180,000 t), and the value of mutton exports was up by 76%. The drivers for the export of sheepmeat were the decline in sheep numbers around the world, a partial substitution in the world meat market of sheepmeat for beef in response to disease scares and exchange rate differentials, and improvements in supply chain management and marketing. Paralleling the increase in sheepmeat exports, Australian beef and veal exports are forecast to rise by 1.5% to 940,000 t in 2001-02, after rising by an estimated 9 % in 2000-01; due to increased slaughtering, cattle numbers in

Australia have remained relatively constant at 26-27 m over the last few years (ABARE, 2001).

Flock and herd structure

In response to steadily increasing lamb prices and declining wool prices, Australian producers have moved away from wethers towards ewe-lamb operations. This shift in flock structure occurred in not only the traditional wool and lamb producing areas but also the cropping zone, where producers moved rapidly during the 1990s to „prime" lamb production (British breed sire over a Merino or 1st cross ewe). For example, a survey conducted in 2001 in the Mallee region of Victoria revealed that more than 85% of farmers had a prime lamb enterprise, compared with 31% of farms with a self-replacing merino enterprise and 21% a merino wethers enterprise (S. Robertson, pers comm). In WA, the proportion of „prime" versus merino lambs is smaller but ewes (66%), compared with wethers (13%) and hoggets (21%), now dominate the flock structure in WA. In NSW, similar changes have occurred (A. Bowman, pers comm), and presumably the changes in SA and Tasmania are in line with these national trends.

In Table 1 can be found recent statistics, collected by the Australian Bureau of Agricultural and Resource Economics (ABARE), on the sheep flock structure and beef herd for farms in the „high rainfall" zone (HRZ) and „wheat-sheep" zone (WSZ), as defined by ABARE. A feature of these statistics is the current importance of the WSZ for red meat production. In 1999-2000, total sheep numbers were 72.9% more, and beef numbers only 2.7% less, than the numbers in the HRZ. In addition, the reproductive capacity of the sheep flocks was considerably more on farms in the WSZ, where the ratio of ewes to wethers was 3.6:1, compared with 1.6:1 in the HRZ.

In addition to the trends in flock structure, there are a number of changes that are occurring in the feed base for livestock production. Below, these trends are given for each of the main production zones.

Table 1. Land use and livestock numbers on properties in the wheat-sheep and high rainfall production zones, Australia 1999-2000 (source, ABARE)

Selected variables for broadacre industries Average per farm values	**Zone**	
	Wheat-sheep (predominantly ley pastures)	High rainfall (permanent pasture zone)
No. of farms	41,192	26,138
Area per farm total ha	1944	1019
Area per farm cropped ha	470	56
Area per farm total fertilised ha	425	234
Area per farm pasture fertilised ha	48	198
Sheep flock (no. at 30 June)	1502	1369
Ewes (no. at 30 June)	826	653
Lambs (no. at 30 June)	427	302
Wethers (no. at 30 June)	229	399
Beef herd (no. at 30 June)	168	272

The feed base in the high rainfall zone - permanent pastures

In the HRZ, in areas such as the Northern Tablelands (NSW) and south-western Victoria, permanent pastures (those that are rarely, if ever, cultivated) are the mainstay of the production system. Unlike the WSZ, the opportunities to replace the components by cultivation and seeding are infrequent and expensive. The most powerful management technique to boost livestock production from the feed base is through the application of fertiliser, while subdivision, stocking rate, grazing management and weed control are other
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forms of management intervention. The level of production on each farm is an outcome not only of the quality of the land and seasons, but also a consequence of the skills and attitudes of the partnership that is managing the farm.

Red meat producers are responding not only to the production and marketing opportunities but also to environmental issues such as biodiversity, landcare and salinity. In the 1990s, some producers „dropped out" of the production treadmill in favour of low-input management regimes that retain native species, maximise ground cover, encourage biodiversity and minimise environmental degradation. As noted in both the MLA Lamb and Sheepmeat R&D Program Strategic Plan (2001) and the MLA Southern Australia Beef Program Survey of Producer and Provider Requirements (2001), increasing the adoption and utilisation of deep-rooted perennial pastures is a key driver for more productive and sustainable grazing systems. MLA supported the Sustainable Grazing Systems (SGS) program to develop the principles, tools and indicators for improving the profitability and sustainability of grazing systems. Despite anecdotal reports of pasture decline, there is no significant disillusionment with the performance of improved pastures that are maintained with moderate to high inputs of fertiliser and management. However, producers are concerned with the relatively unreliable persistence of some species and the high cost of pasture re-establishment. While many producers are now reinvesting in new varieties and/or fertiliser for productive perennial pastures, some are likely to retain their low-input philosophy.

Developments in the wheat-sheep zone - ley pastures

A number of significant developments have occurred in the WSZ, and more are anticipated. During most of the 1990s the relative profitability of grazing animals declined relative to crop enterprises on farms. The implementation of crop monitoring protocols was at the heart of the adoption of pulse and oilseed crops, which in turn helped lift crop productivity on farms by 33% Australia-wide during the last decade. However, the current skill base in pasture management is low in this zone, constrained as it is by attitudes and lack of investment. In 1998, an ABARE survey was conducted on farms designated as „crop specialists" (C) and „mixed livestock crop enterprises" (LC). The proportion of the farm area comprising pasture was 42% (C) and 61% (LC), and the proportion of pasture sown in the year preceding the survey was 20% (C) and 13% (LC). In both enterprises, less than 10% of the pastureland received any fertiliser (see Table 1), a finding that in part reflected the common practice of growing pasture on the residual nutrients applied to crops. Most producers in the ABARE survey rated their pastures as „good" (34%) or „reasonable" (59%) rather than „poor" (7%). However, assessments by pasture specialists, such as the one conducted by Rigby and Latta (1995) in the Victorian Mallee, indicate a different picture - the legume content of the pastures was „poor" or worse on more than two-thirds of the pasture area surveyed. Recently, improved livestock prices and problems associated with a longer phase of cropping (disease management in broadleaf crops, herbicide-resistant weeds) have increased the interest of many producers in the pasture-animal phase of the rotation. The interest was also stimulated by better pasture management protocols (such as

PROGRAZE), as well as (in WA) the expected availability of an expanded array of legumes (and management packages togo with them) for sowing in the cropping zone.

R&D Investment and Output

This is another area of considerable change, involving reduced commitment by universities and State agriculture departments to public-good R&D, the development of multi-agency approaches to R&D management, and an increasing proportion of the pool of R&D funds coming from R&D Corporations and the private sector. Some of the threatening developments will be dealt with in the section that outlines the changing scene for activities and investment in pasture plant improvement (see later). On the other hand, there are also some positive trends. The first is that public and private R&D bodies are more efficient now than they were 10 years ago in selecting, monitoring and promoting the outputs from agricultural research. For example, the GRDC bases its management of R&D projects on the outputs and outcomes that they produce for the grains industry. Communication strategies used by GRDC to contribute to the rise in wheat productivity on Australian farms during the last decade, from 1.51 t/ha (1987/88/89) to 1.91 t/ha (1997/98/99), include investments in PIRDs (producer initiated R&D), forums and updates for advisers and farmers, an industry newspaper, sponsorship of products and the use of the TOPCROP brand for delivering crop monitoring tools. Another R&D development, one that is significant for the future of pasture improvement, is the number of recent reviews dealing with pasture plant improvement and pasture management (see Bibliography). The evaluation of the investments made by MLA in pasture improvement, particularly in the breeding/selection of new cultivars of pasture plants, must be set against the outputs and outcomes that have occurred in comparable industries, such as the grains and dairy industries.

Objective 1. Review previous MLA and MRC investments in pasture plant improvement and evaluation and identify the impact for sheepmeat, lamb and beef producers

Levels of investment

The financial year 1989-1990 saw the start of considerable investment by MRC/MLA in pasture plant improvement which has totalled almost $6.4m since then. Support of some $100,000 in 1989-1990 grew to more than $1m in each of the financial years 1994-1995 and 1995-1996. Since then, it has declined to $10,000 in 2001-2002. Details of annual MRC/MLA investments in specific projects, together with total annual support provided, is included as Appendix 2.

After the review was completed, it was discovered that there were a number of additional projects [listed as Appendix 2A], which had been supported either by the then Australian Meat and Livestock Research and Development Corporation and/or MRC, and had not been included in our deliberations. Few details of these projects are available and it was agreed with MLA that they would not be considered in our response to Objective 1 of the review.

Brief assessment of projects supported

Much of the information required for the following summaries was provided by MLA However, it was necessary to augment this by directly approaching many of the researchers involved in the projects to obtain up-to-date facts, figures and expectations needed for a better overall perspective of outputs and outcomes. Such discussions also resulted in our

gaining access to a number of publications and reports pertinent to the projects and led to a copy of the only benefit:cost analysis of a project that we have been able to obtain.

1. Breeding Improved Perennial Ryegrasses for Temperate Pastures in Australia
   Project number DAV 094 [Supported 1993-1997]

Total MLA Investment $ 759,962

Overall Program Objective
Breeding improved [persistent and highly productive] cultivars for specific areas of Australia to increase meat and milk production.

Project objectives
By 1998, to develop at least one cultivar for each of categories

(i) with improved winter growth,
(ii) improved autumn growth and drought tolerance, and
(iii) improved seasonal and late seasonal growth. In addition, at least 2 synthetics with improved seasonal growth and late maturity were to be available for bulking and release in the year 2000.

Outputs.
Fitzroy, a persistent and adaptable cultivar with improved winter growth [category (i) above] was released in 1998 [with Wrightson Seeds as commercial partner], primarily for sheep, beef and prime lamb production systems.
In addition, Avalon, a persistent and widely adapted perennial ryegrass cultivar, with superior autumn and winter growth and a high seed yield, was released from the core program in 1999. It was developed especially for dairy and prime lamb production. Vic Seeds is the commercial partner.

Outcomes.
In 2001, 47 t of seed of Fitzroy were sold, the majority for sowing in southern NSW, Vic and SA, largely at the expense of Kangaroo Valley. Some 67 of seed are expected to be sold in 2002 and pastures sown to Fitzroy are likely to extend to new areas of southern NSW. Ninety-five tonnes of Avalon were sold in 2001, with estimated sales of 120 t in 2002, sufficient to sow 10 000 ha. The cultivar is widely grown in Vic, southern NSW and SA, mostly replacing Victorian ryegrass and older NZ varieties.

Further expected outputs.
As a result of a favourable review undertaken in 1998, and some initial difficulties in obtaining commercial partners for marketing the improved material, a number of changes were made in the focus of the program. Nevertheless, the commercialisation of Fitzroy and Avalon represented major steps in achieving the objectives of the program - to deliver improved cultivars with greater persistence, higher total yields, improved seasonal production, autumn growth and drought tolerance. These objectives should be met fully following the expected release of two other cultivars of perennial ryegrass, namely: -

AVH-13/14 (from category (iii) of DAV 094 and scheduled for release in 2003), a late-season grass for dairying, and

AVH-4 (category (ii) of DAV 094, for release, with Vic Seeds as commercial partner, in 2004), a persistent and productive variety, derived from Mediterranean material, for sheep and beef grazing in pastures in the marginal perennial ryegrass [500 - 600 mm rain] zone.

Two further perennial ryegrasses from the breeding program are due for release within the next few years: -

AVH -17 (from DAV 384, largely supported by DRDC, but with some early funding from MRC, for release in 2005), a winter - late season cultivar for late season lamb and dairying

AVH - 32 (for release in 2004) an adaptable and persistent cultivar for sheep and beef, selected from Victorian material, and broadly similar to Avalon but suited to more marginal conditions.

2. Tall Fescue Improvement for Specific Areas in Australia

2a Tall fescue improvement for winter growth, seedling vigour and productivity
DAV 095 [1993-1997] **Total MLA investment $ 165,573**

2b Commercialisation of DAV 095 material
TR. 028 [1997-1999] **Total MLA investment $ 97,592**

Overall Program Objective.
To develop tall fescue cultivars with superior performance in seedling vigour, winter growth, total productivity and better quality herbage for defined climatic zones in Australia. The improved cultivars were expected to both replace existing tall fescue cultivars, thereby increasing the productivity of present pastures based on the plant, and expand the area of tall fescue in Australian temperate pastures.

Specific project objectives
[DAV 095] To produce an improved winter active/summer dormant cultivar
[TR. 028] [i] Multiplication of seed of the winter active/summer dormant selection, and, [ii] Selection and seed multiplication of summer active accessions with superior winter growth for the „northern temperate winter rainfall" and the „southern summer rainfall" environments.

Outputs
[DAV 095] A winter active/summer dormant cultivar, Fraydo, derived from cv Melik [a tall fescue selected from a Mediterranean population], was developed for sheep, prime lamb and beef on pastures in low rainfall (500 - 600 mm), short grazing season temperate environments, typified by parts of SW Victoria. The persistent, adaptable and drought resistant cultivar had improved winter growth (50%), seedling vigour (40%) and density (40%) when compared with Demeter and AU Triumph, the only two approved tall fescue varieties available in Australia in the early to mid 1990s. Fraydo was released in 2001 following its commercialisation with Plant Tech Pty Ltd as the partner company.

[TR. 028] Three superior summer active accessions were identified following evaluation trials at Glen Innes and Hamilton. One, presently being commercialised by SGB [now part of Plant Tech Pty Ltd] is being evaluated in APPEC trials.

Outcomes.
Fraydo is now grown quite widely in NSW, Vic, SA and Tas, on a total of some 2500 ha. Seed sales, which were 25 t in 2001, are estimated to fall to 10 t in 2002 because of the limited seed available, and to rise to 30-40 t in 2003. Trials to determine optimum management strategies are being undertaken on the two cultivars developed in project TR. 028.

3. The South Australian Lucerne Improvement Program

3a DAS 021 [1989-1993] **Total MLA Investment - $ 369,223**

3b DAS 030 [1992-1997] **Total MLA Investment - $ 907 082 and reinvestment of royalties since 1997**

Program Objective.
Development of improved cultivars for several of the 7 recognised lucerne growing zones in Australia. Up to 1997, when project DAS 030 was completed, the priorities of the improvement program were Zone 7 [the temperate high rainfall regions] and Zone 1[the semi tropics/east coast]. Zone 4 [the cool wet regions] and Zone 6 [the south and south west areas of Australia] were also targeted. Whilst meat is a key industry in all 7 zones, MRC appears to have been mainly interested in Zone 7. Nevertheless, it seems that support was provided for the core breeding activities (The extension of the program during the past few years, e.g. the targeting of WA to include saline soils [supported by GRDC] and the ACIAR project focused on China, are outside the scope of this review).

Outputs.
New varieties, marketed by the commercial partner, Heritage Seeds, and released during the past decade include:-

Sceptre [released in 1992], winter-active broad purpose cultivar suitable for irrigation, hay and dry land up to 5/6 years

Eureka [1993], winter-active cultivar suited to dryland production on a range of soils from cold wet areas of S and SE Australia to Queensland

Jindera [1993], a diploid prostrate, creeping, niche cultivar with little winter growth, suitable for soil stabilisation e.g. on slopes Super Seven [2000], reasonably winter-active, grazing-tolerant and disease resistant. Its fine leaf and stem makes it a premium hay cultivar whilst it is very adaptable, being suited to a wide range of conditions from the Eyre and Yorke peninsulas of SA, through Queensland, NSW to S Victoria and Tasmania. Its use has also spread to the drier cereal/livestock zones.

Expected outputs.
Super Ten [to be released in 2002], will be the most winter-active cultivar available, very adaptable to a range of climate and management, including dry land and irrigation, highly resistant to aphids, phytopthera and anthracnose and resistant to stem nematodes. This short-lived cultivar - the first true synthetic produced in the program - is a high yielding, high energy plant developed to maximise production under a hay and/or rotational grazing management. It also has a high seed yield. Super Sleepy [expected to be released in 2005], a low winter active synthetic. Super Salty [planned for release about 2005], for saline soils.

Outcomes.
Sceptre and Eureka are said to have been the top 2 performing cultivars across 13 sites in NSW. Sceptre has been the best selling variety, averaging some 120 t/annum over the past 5 years, with sales for Eureka being 80 - 100 t/annum. In contrast, sales of the specialised cultivar, Jindera, have reached annual sales of only about 1 t. Shortage of seed has restricted sales of Super Seven to 25 t in 2000/2001.

Expected outcomes.
Sales of Super Seven are expected to increase to 50 t in 2001/2002. The cultivar, with its greater nematode resistance, could ultimately replace Eureka, even though both this cultivar and Sceptre continue to sell well. Super Ten is said to have great seed sales potential, with

100 t/annum a realistic short-medium target. It is too early to assess the potential of either Super Sleepy or Super Salty.

Benefit:Cost analysis An assessment of the Breeding Program between 1978 and 1994 (Black, 1995) showed a benefit/cost ratio of 22.3:1 at a 5% interest/discount rate and13.3:1 using a 10% rate, with an internal rate of return of 86%.

4. White clover breeding for dry land beef/sheep environments
TR. 041 [1997-2002] **Total MLA Investment $ 120 000**

Overall Program Objective
To develop superior cultivars for dryland beef and sheep pastures using Australian and New Zealand expertise and world sourced germplasm. One such cultivar from the program, Grasslands NuSiral, which is well adapted to most white clover environments, was released commercially in 1999.

Project Objective
To release at least one superior white clover cultivar by 2001. This objective was developed as the second 3 years of a 6-year breeding cycle, following a 3-year assessment of promising accessions to identify plants for polycrossing

[DAN 085]. It involved an evaluation of breeding lines derived from such polycrosses, and concurrent testing of the seed production capacity of experimental cultivars, registration for PVR and commercialisation.

Outputs.
All contracted milestones are said to have been met. Processes are in place for the seed multiplication of two experimental varieties. Germplasm has been prepared for a further project to develop a drought-tolerant cultivar for low rainfall environments

Expected outputs.
A „TR. 041" cultivar, for dryland pastures in summer moisture stress environments, is expected to be released in 2003.

Outcomes.
It is premature to determine the outcomes or impacts of the project.

5. Screening phalaris accessions and breeding lines for safe levels of tryptamines and two selected toxins

CS 210 [1993-1997] **Total MLA Investment $ 293 072**
[AWI has made significant contributions to the core phalaris improvement program]

Objectives.
To investigate the important problem of sudden death of stock grazing phalaris, thought to be due to a range of toxins. Specific objectives were to:-

• analyse accessions and breeding populations for concentrations of alkaloids and other poisons
• if any low toxicity plants were found, (i) produce sufficient seed to establish field trials in areas prone to frequent phalaris poisoning, (ii) cross low toxicity plants and evaluate progeny to determine level of heritability, and (iii) cross low toxic plants to current breeding populations and backcross to selections as first step in breeding low toxic cultivars in a range of phalaris types

Outputs.
Heritable variation in toxin concentration found in 50 accessions and two cultivars. Plants were clonally propagated to produce seed for field testing of experimental population [LoTox] at site in SA. The problem of deaths of hungry sheep feeding on phalaris remains unsolved.

Outcomes.
No industry outcomes, as yet. Any benefits (reduced stock mortality and wider use of phalaris) dependent on the development of safe [low toxin] cultivars.

6. Commercialisation and Development of an Agronomic Package for *Microlaena stipoides* for Forage and Other Purposes

UNE 039 [1993-1998] **Total MLA investment $462,463**

Objectives
To develop packages to improve the establishment and seed production of *M. stipoides,* the two factors apparently most limiting to the widespread use of the plant in profitable and sustainable pasture systems in high rainfall areas.

Outputs.
Whilst considerable agronomic data have been collected, the two objectives do not appear to have been fully met. Initial failures of seed crops in Australia resulted in seed now being produced in New Zealand.

Outcomes.
It is too early to make any reasoned assessment.

7. LIGULE [Low input grasses useful in limiting environments]
M 551 [1994-1998] **Total MLA Investment $ 218 482**

Objective Selection, by June 1998, of at least one native grass with the potential to :-

- reduce soil water to at least the same extent as phalaris
- grow weaner sheep or cattle
- be readily commercialised

The multidisciplinary, team-based project involved (i) field evaluation of spaced plants of 20 previously identified promising native grasses [LIGULE grasses] and 4 commercially available perennial grass varieties, undertaken for 4 years at 4 sites in Victoria and NSW, and (ii) a series of parallel investigations on seed germination, seed production technology, root growth and response to applied nutrients.

Outputs.
Four native grasses persisted better than phalaris, with Consol lovegrass [C_4] the most persistent, and with some producing dry matter in winter. The investigators expressed confidence that selected LIGULE grasses could grow weaner sheep or cattle by adding to the availability and quality of existing hill land pastures. There was evidence that summer active LIGULE grasses reduced soil water, and thus the potential for deep drainage, more than phalaris. Several accessions appeared to have good potential for seed production.

Industry outcomes.
Whilst going a long way to achieving the objectives of the project, significant industry outcomes remain dependent on converting these promising results into practice. None of

the material has yet been developed to the stage that it can be released. The researchers appreciated that this depends on defining, and then achieving, further [economic, water balance, pasture establishment, productivity and management, seed production and technology transfer] goals.

8. Native and Low Input Grasses Network (NLIGN) - Multisite Evaluation
TR. 045 [1997-2001] **Total MLA Investment $ 90,000**

Objective.
To evaluate the performance [particularly the persistence and DM production] of a number [58] populations of native and low input grasses, grown as spaced plants in low fertility conditions at 8 sites in southern Australia. These sites ranged from the high rainfall permanent pasture zone to drier mixed farming regions and to the Mediterranean permanent pasture of WA. (In addition to MLA, 6 other bodies - NSW Ag, UNE, TIAR, DNRE, SARDI and Ag WA - contributed to the project).

Outputs. Robust agronomic data on natives and low input exotics have been collected in southern Australia . Five accessions were selected for further development.

Outcomes. It is too early to evaluate the potential outcomes in terms of seed availability, uptake and economic benefit. A proposal has ben developed for inclusion in the opportunities recommended for future MLA investment. The proposal seeks to extend the evaluation of these accessions beyond the present 3 years, with parallel investigations on establishment, sward performance and seed production.

9. Genetic engineering of forage legumes for bloat safety and improved nutrition
Support was provided for three stages of the project, namely : -

9a Phase 1 CS 114 [1990-1993] **Total MLA Investment $ 274,378**

9b Phase 2 CS 184 [1992-1996] **Total MLA Investment $ 1,012,904**

9c Phase 3 TR. 014 [1996-2000], extended [as TR. 014B] until September 2002
Total MLA Investment $ 715,145

Overall objective
To reduce the incidence of bloat by producing genotypes of forage legumes containing condensed tannin in their leaves. The aim was to produce, by 2003, commercially available seed of a bloat resistant lucerne and/or clover through the introduction from other organisms of the gene[s] for proanthocyanidin [condensed tannin].

Methodology
Genetic engineering was used to isolate and transfer to white clover a single missing gene coding for a tannin enzyme; tannin confers both bloat safety and increased protein use efficiency.

Phase 1 CS 114

Objectives To define and purify, by June 1992, the critical biosynthetic enzymes required for foliar tannin synthesis in white clover and lucerne

Outputs A key enzyme has been identified and purified to a level where it is expected that monoclonal antibodies can be produced. Transgenic white clover plants, which carry and express foreign genes, have been produced. [Transformation methodologies for

commercial cultivars of lucerne and subterranean clover have also been developed by CSIRO staff]

Expected Outcomes Antibodies can be produced and the amino acid and sequence data obtained. The transformation scheme developed appears applicable to several commercially important cultivars. It provides a way of introducing the isolated gene into white clover. Bloat safe and nutritionally improved cultivars of white clover, lucerne and subterranean clover should be possible in the next phase of the project.

Phase 2 CS 184
Objectives
To (i) clone the gene for leucocyanidin reductase by July 1994, and
(ii) engineer the gene and produce transgenic white clover with leucocyanidin reductase activity and tannin accumulation in the leaves by June 1996.

Outputs
The methodology used indicated that the required gene has been cloned. Other achievements : -

• More than 500 white clover plants transformed successfully with an efficiency of 25-70% transformation
• increased understanding of tannin synthesis and development of molecular tools to study tannin
• Preliminary patent applications lodged

Not all objectives were achieved. Nevertheless, after a favourable review of the work, undertaken in June 1996, funding was provided for the third phase of the project.

Phase 3 TR. 014 [including TR. 014 B]

Objectives
To confirm [i] that the required gene [LAR cDNA] has been cloned and is expressing the correct protein, [ii] the presence and expression of the gene in transgenic clover, and [iii] demonstrate functional levels of condensed tannins in vegetative tissue of transgenic white clover.

Outputs
Explanation of why previous attempts to express enzyme activity had failed. Enzyme activity successfully expressed in *E. coli.* [TR. 014 B] Gene cloned and characterised. Confirmation of presence and expression of gene in transgenic plants.

Expected outcomes
Presence and expression of gene in transgenic clover confirmed by measuring increased tannin levels. Demonstration of functional levels of tannins in vegetative parts of transgenic white clover.

Industry outcomes of overall project
None at present though the researchers remain optimistic that a potential gain of $100-$200m/annum to the Australian livestock industry is attainable. However, the estimated date for achieving this has been revised, with 2008/9 being the present estimate for the release of a bloat safe cultivar. Outcomes of research are subject to commercialisation agreement involving CSIRO, MLA and Pioneer Hi-Bred International [PHI]. (PHI is investing significant resources with CSIRO to develop bloat safe lucerne).

10 Technology Adoption of Tall Fescue
AGRES 001 [1994-1999] **Total MLA Investment $ 403,390**

Objectives.
To increase rate of adoption of new tall fescue cultivars.

Outputs.
New cultivars of tall fescue, grown in on-farm demonstration plots, produced measured live weight gains in both sheep and cattle and increased protein content of herbage, of 25% or more greater than those recorded from plots of perennial ryegrass, phalaris and old varieties of tall fescue. Whilst the results and their interpretation might be questioned, the reported increased output from new tall fescue varieties in animal production [generally] and in net farm income [$233 at one site] are clearly of relevance to the present review. The results could also be highly significant for the expanded use of tall fescue.

Outcomes.
No economic analysis of on-farm benefits was undertaken to measure the outcomes. Further, no mention is made of any follow-up project to either determine target markets or test the claim that the project has contributed to either the adoption of tall fescue or changes in management practice.

11. Lotus Grazing Management for Weaner Production
DAN 082 [1994-2000] **Total MLA Investment $ 335,243**

A project designed to investigate, on evaluation and demonstration plots, the potential for lotus-based [thus bloat-free] pastures for beef in the high rainfall zone.

Objectives
Maintenance of at least 30% of lotus [*Lotus uliginosus and/or L. corniculatus*] in pastures for a minimum of 4 years, the design of a suitable system of management for, and the promotion of the agronomic and economic value of, lotus species.

Outputs included major differences in the establishment and persistence of lotus lines under different managements in 4 distinct geographic locations, thus contributing to our knowledge base on the species.

Outcomes were said to be increased awareness of those participating in the study [graziers, extension officers and seed companies] of the potential of lotus, though there is no indication as to how this was measured. There was no economic analysis nor any evidence of further extension activities. It would also have been illuminating to learn what effect the work had on the use of lotus.

12. Permanent Summer Forage - Development of chicory to fill the feedgap
DAN 070 [1992-1996] **Total MLA Investment $ 117,999**

Objectives
To develop agronomic practices to use chicory to fill the summer feedgap in the high rainfall zone of temperate Australia. Specific objectives were to : -

• compare chicory and lucerne for lamb production
• determine the grazing management for chicory pastures to ensure optimal persistence and productivity
• determine the appropriate mixtures for chicory pastures for optimal productivity and weed management

• identify selective herbicides for early post-emergence use, optimal sowing rates, response to nitrogen fertiliser and other management factors to complete a management package for chicory

Outcomes
Lambs grow as well or better on chicory as on lucerne and meet most market specifications. The plant is valuable for fat lamb production, especially where annual rainfall exceeds 600 mm and where soils are deep. Chicory is more flexible to manage and has greater adaptability than lucerne, whilst chicory mixtures are better for fattening lamb in NSW than perennial pastures. Management packages have been developed with recommended sowing rates, companion species, grazing management and weed control.

13. Investigation of Potent, Secondary Toxicity of ARGT
PICU 106 [1999] **Total MLA Investment $ 34,670**

Objective.
To explore the potential negative effects of ryegrass toxicity, specifically to establish any toxic effect on consumers of cattle exposed to corynetoxins [fungal toxins].

Outputs.
No secondary toxic effects from eating meat from cattle with clinical symptoms of ARGT were detected. Thus, ryegrass containing the toxins did not contain sufficient residues of the poison to cause health problems for consumers.

Outcomes.
Increased confidence in the use of ryegrass.

14 . An Assessment of the Global Market for Lucerne
CS 278A [1996] **Total MLA Investment $ 10,850**

Objective
To assess the potential of a bloat safe gene in grazed lucerne, an important component of the feed base of ruminants. [The results of this market research were intended for possible use in a commercial tender document]

Outputs.
Whilst the review produced some estimates of the global market value of lucerne seed, hay and processed products, its main intended objective, the potential of the transgenic material in grazed lucerne, proved „too difficult to quantify".

Outcomes. No implications for the commercialisation of the gene are reported in this unsuccessful project. The results were irrelevant to the expected outcome and had little or no overall impact.

15. APPEC [Australian Pasture Plant Evaluation Committee]

Funding has been provided for the development, organisation and management of APPEC [some $5000/annum for 6 years] through supporting the salary of the Co-ordinator, Permanent Pasture Plant Improvement Program. A method of assessing cultivar performance, agreed between the public and private sector, was an important objective in the early 1990s.

Objective
Establishment of protocol for the evaluation of pasture plant cultivars.

Output
Successful establishment of agreed protocol, which operated for some 6 years

Outcomes Some justified criticisms [e.g. performance judged largely on DM production in small monoculture plots, usually cut rather than grazed and sometimes producing highly variable data, cost, and a limited number of testing sites], undermining, and the decision of The Seed Industry Association of Australia [SIAA] not to share in the direct funding of the scheme, led to its abandonment. Nevertheless, APPEC has had a major influence on changing the attitude of SIAA to cultivar evaluation and on the way information is presented in company brochures. Further, the APPEC protocol has been incorporated into the code of practice of SIAA [a legal document subject to the Trade Practices Act], with the conduct of SIAA members [in using cultivar performance data] also subject to the body"s code of conduct.

General impressions and conclusions

Considerable difficulty was experienced in obtaining the necessary data and information needed to fully meet the first objective of the review, largely because of deficiencies in MLA"s procedures for project reporting and record keeping. The Company needs to improve these procedures [see Recommendations - pp 18-19]. Some of the original summaries of the relevant projects were not very helpful. Information was presented in a far-from-uniform manner. Further, on occasion, the reported outputs were simply a restatement of the project objectives and did not make clear what had, and what had not, been achieved. Outcomes and industry implications, needed for assessing the impact on the red meat industries, were barely considered in some reports.
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Nevertheless, it is possible to draw a number of conclusions. Most projects in which MLA has invested have generally achieved the agreed objectives [though, predictably, the original time frames have sometimes been optimistic]. Two projects, [1, Breeding Improved Perennial Ryegrasses, and 3, The South Australian Lucerne Improvement Program] have been particularly successful in developing new cultivars. The objectives of the projects on biotechnology [project 9], the native grass *Microlaena stipoides* [project 6] and phalaris [project 5] have not been fully achieved, nor are they likely to be without some further support. Typical of any program of research funding, a few programs have either failed [project 14], been aborted [project 10] or given rise to claims which appear unwarranted, or require further work to verify [projects 10 and 11]. Publications, a feature of most of the projects supported, have provided a valuable by-product. Extension leaflets have assisted in technology transfer whilst most scientific publications have added to our store of knowledge.

The most telling measure of the effectiveness of the MLA investment would probably have been a comparison of its effects with those of the support given by GRDC and DRDC in the selection, breeding and evaluation of new pasture plants. Any such comprehensive analysis would require a major investigation outside the scope of this review. However, our experience and knowledge leads us to believe that GRDC investments in pasture plant improvement have assisted in achieving gains in output greater than the 1-2% expected from conventional breeding. Such gains have included those from reduced formononetin levels and increased pest and disease resistance in improved cultivars in key WSZ legumes. Further, the selection of alternative legumes from GRDC-supported projects is also producing a significant impact. DRDC investments in pasture plant improvement [a number in projects also supported by MLA] have resulted in some impact, partly covered in considering work at the PVI (pp 7-8).

We have therefore made a general comparison of the outputs of MLA-supported projects, and thus on their objectives being achieved, with those of a number of university research funding schemes. On this basis, we conclude that MLA has generally invested appropriately in assisting the selection, breeding and evaluation of pasture plants. We particularly applaud the support which has been given to well-established and successful researchers who worked within the National Pasture Plant Improvement Program [see later], who have developed a number of improved, high-performing cultivars.

It is less easy to judge the impact of past MLA investments on the red meat producers. Increased awareness of the value, and the adoption, of some plants, changes in management practice, animal liveweight gains and improved farm incomes, have all been claimed as outcomes of some projects [e.g. 10 and 11]. Whilst it is clear that at least one project [number 14] has had little or no impact, the full extent of the outcomes and impact of most of the others require a longer time period to evaluate. Thus, the information which we have been able to obtain on the projects provides few reliable data to enable any realistic measurement of their industry impact. What is clear is that seed sales of a number of improved cultivars [e.g. some new ryegrass varieties bred at the PVI in Hamilton, and lucernes from the SARDI projects] have been high, markets have been captured, and there has been
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some penetration into new areas. Thus, it is safe to assume that many individual farmers and graziers have been convinced of the value of these new plants, and thus the projects are almost certain to have had some impact.

However, we believe that, so far, the overall industry impact of new pasture plants has been relatively limited. There are a number of reasons for this conclusion. First, improved cultivars from most pasture plant improvement projects in which MLA has invested either have only recently become available commercially, or are not yet on the market; thus insufficient time has elapsed since the completion of the projects to determine the extent of adoption of these improved varieties, and thus their impact on pasture productivity. Secondly, the potential of improved cultivars on animal production depends on management, which is often well below the desirable standard in pastures which form the feed base of the red meat industries. Further, much of the MLA support has been made in projects to develop cultivars for permanent pastures in the HRZ zone, where some plants, especially a number of the grasses, used widely prior to the company"s investment, were reasonably well adapted to the growing conditions; this allowed only marginal improvements to be achieved.

Nevertheless, we would be surprised if there had not been a significant impact both on the animal enterprises and the net farm income of farmers and graziers who have (a) sown the new cultivars, with their clearly evident improved traits (e.g. potential for higher production of quality feed, out of season growth, or resistance to damaging diseases and pests, this latter resulting in longer-lived pastures) and (b) managed their pastures well. Some agribusinesses are now offering packaged services to producers based on the establishment, fertilisation and utilisation of novel pastures mixtures. We expect the overall impact of the MRC/MLA investments to increase in the next few years as a result of the greater use and better management of the newly released pasture plants, ultimately becoming quite considerable.

We are also confident of an even greater potential increase in animal production and in farm income in areas presently lacking pasture plants adapted to the prevailing growing conditions. The selection of persistent and productive varieties for such areas, especially of legumes, is almost certain to have a very positive impact on red meat producers.

MLA should take steps to evaluate outcomes and impacts of projects already completed [and of any supported in future] by monitoring effects over time. A benefit:cost analysis needs to be undertaken on a sample of recently completed projects to provide a monitoring framework, with adoption and impact assessed every 2-3 years over a period of 5-10 years. If no significant adoption of improved cultivars is apparent 5-10 years after the conclusion of a project, it is unlikely that they will have much impact on pasture productivity.

Recommendations

We suggest : -

1 A common method of presentation of milestone and final reports in which the project objectives, outputs and, where appropriate, outcomes and any industry impacts are clearly shown

2 Summaries should be made of projects already completed, with particular emphasis on output and outcomes/expected outcomes. This would not only facilitate the MLA reporting process, but would also provide a framework for further monitoring of adoption [early stage outcomes] after projects are completed. Such a structured summary could be made a mandatory part of final milestone reports

3 Summary information on projects [agreed objectives, outputs and any outcomes and industry impacts] be included in a computer data base for online access. The existence of the projects should already be recorded on ARRIP

4 a benefit:cost analysis be undertaken on a sample of recently completed projects to monitor and evaluate outcomes and impacts over a time period and results included in the data base. Such analyses should be undertaken on all future projects

5 Independent reviews of large projects - including benefit:cost analysis if appropriate - when the level of investment exceeds $500 000 or after 5 years.

Summary

Our response to Project Objective 1 can be summarised thus : -

° Within the limits of the information available, we conclude that the Corporation's investments have generally been appropriate

° Most projects have achieved their objectives. Some have been particularly successful, especially the DNRE perennial grasses and SARDI lucerne improvement programs, each of which has produced a stream of new cultivars which have been received favourably by the wider industry. A number of other projects, whilst producing valuable information, have not met their objectives fully; they include the projects on biotechnology, the native grass *Microlaena*, and toxicity screening of phalaris. A few - Technology adoption of tall fescue and Grazing management of lotus - have given rise to claims which require further work to verify. Only one project - Assessing the global market for lucerne - can be said to have been a complete failure

° MLA-supported projects are presently not well geared to provide reliable information on outcomes and industry impacts

° A number of recommendations have been made on : the form of project reports to MLA; project reviews; provision and on-line storage of project summaries, including objectives, outputs and outcomes and industry impacts

° Deficiencies in MLA procedures were largely responsible for our difficulties in obtaining the comprehensive, reliable information required to properly evaluate the MRC/MLA investments.

Significance of R & D in pasture improvement - assessments by stakeholders

Our conclusions on the MLA/MRC supported projects relied in large part on information provided by the researchers involved, through milestone and final reports, or directly through responses to specific questions. However, we felt it important to seek a broader assessment of the impact of pasture plant improvement from a wider group of stakeholders in the red meat industries. This assessment was necessary to:-

° consider how well R & D in pasture plant improvement had met the needs not only of red meat producers but also the wider community and industry (Objective 1)
° provide a general appreciation of the past, current and future „landscapes" for pasture improvement, and
° provide a platform for considering specific opportunities for further pasture improvement (Objective 2).

The stakeholders who were surveyed included farmers and graziers, extension workers, consultants, administrators, researchers, other R & D Corporations and seed company executives. We also wanted to find out how much was known of MLA"s involvement in, and contribution to, pasture plant improvement and to pasture improvement overall.

Methodology

The review team prepared five questionnaires [included as Appendix 3], with Gabrielle Kay and Cameron Allan from MLA also providing input into the process. The questionnaires were designed to assess pasture plant improvement in a wider industry context, as seen through the eyes of particular groups of stakeholders. The stakeholder groups were : -

1. Graziers/Farmers, Administrators, Extension workers and Consultants
2. Plant Breeders and Research Agronomists
3. Biotechnologists
4. Seed companies
5. R & D Corporations

Some 100 people, drawn from all States in southern Australia [New South Wales, Victoria, Tasmania, South Australia and Western Australia] and from New Zealand, participated in the survey [see Appendix 4]. Visits were made to R & D/industry centres in Armidale, Tamworth, Orange and Wagga (NSW), Canberra (ACT), Hamilton, Melbourne, Rutherglen, Birchip and Walpeup (Victoria), Adelaide (SA), and Perth (WA). Most participants were interviewed, either face-to-face or by telephone. In addition, a number of very helpful written responses were received. Further, several interviewees provided, or referred us to,

published papers and reports; these and on-line ABARE data proved sources of valuable information.

Pasture improvement in southern Australia

Within the context of this review, the feed base of the red meat industries is based largely on managed pastures in the high rainfall and wheat/sheep zones of southern Australia.

Overview of pasture improvement in the HRZ (NSW Tablelands, North Central Victoria, Southern and Eastern Victoria, and Tasmania). (The naming and geographical boundaries of the zones are those used by ABARE).

During the 1950s and 1960s, large increases in pasture and animal productivity occurred in the HRZ. These increases were a consequence of the introduction and use of pasture legumes and superphosphate fertiliser, coupled with the impact of aerial agriculture. The pasture legumes were either white clover (*Trifolium repens*) in the Northern Tablelands, eastern Victoria, and parts of southern Victoria and Tasmania) or subterranean clover (*T. subterraneum* in the Central and Southern Tablelands, north-central Victoria, and parts of southern Victoria and Tasmania). These „improved pastures" were characterised by higher dry matter production, better seasonal distribution of herbage and enhanced pasture quality when compared with native pastures.

Both white clover and subterranean clover were successfully established by aerial sowing, as well as on conventionally cultivated or sod-sown seedbeds. Introduced perennial grasses (phalaris, cocksfoot, perennial ryegrass and tall fescue) were usually not sown from the air; if they were, their establishment (particularly that of phalaris) was often unsuccessful, and shallow-rooted species (especially perennial ryegrass) failed to persist after droughts.

During the 1970s, there were some minor benefits resulting from the use of low formononetin cultivars of subterranean clover, and the increased use of pasture plants resistant or tolerant to pests and diseases. However, many cultivars released since the 1970s have had relatively little impact on agriculture in the HRZ, even though some contained very desirable traits. For example, the original cultivars of perennial ryegrass (Victorian, Kangaroo Valley), tall fescue (Demeter) and white clover (Victorian Irrigation) are still recommended by Departments of Agriculture. Whilst several „improved" cultivars of phalaris were characterised by marked improvements in seed availability, seedling vigour and winter production, these benefits have not outweighed their poorer persistence when compared with the original Australian commercial variety under set stocking. Furthermore, unlike the Porto cultivar of cocksfoot, no cultivar of phalaris appears tolerant of aluminium toxicity, a problem that occurs on many soil types as a consequence of pH decline. Since 1990, therefore, new cultivars of perennial grasses and legumes in themselves do not appear to have markedly improved either the productivity or sustainability of red meat production.

In contrast to the minimal effects of new cultivars, pasture management has been the key factor in determining the level of productivity from high input pastures. The main ingredients in high input pastures have been the continued use of superphosphate, the strategic application of lime to correct excessive soil acidity in southern NSW and northern Victoria, and moderate to high stocking rates. In the opinion of those surveyed, graziers expressed no significant disillusionment with improved pastures. However, for renovating pastures with new cultivars of legumes and grasses, high input producers demanded ease of establishment and management, even where the technology seemed adequate to establish and maintain such pastures.

Some polarisation is evident in the recommendations for the best plants and management for improving pastures between personnel in State Departments of Agriculture, the traditional sources of information, and representatives of agribusiness, the new elements for change. For example, an agribusiness chain is responsible for most of the advice on pasture improvement on the Northern Tablelands of NSW. This company has a more than 95% success rate for pasture establishment whilst its recommended seeds mixtures and management techniques are endorsed by producers. Agribusiness companies offer producers a bundled set of services. They support the development and use of new, proprietary lines of plant species such as
[i] tall fescue, white and red clover, plantain [*Plantago lanceolata*] and chicory for permanent pastures, and [ii] short-rotation and perennial ryegrass for special purpose fattening pastures. The one gap in an otherwise successful commercial package is the lack of a persistent, competitive legume. A possible role for MLA in providing objective information is considered later.

Pasture components - exotic or native?

Despite the emphasis on exotic pasture species for temperate Australia, native pastures still cover as much as 50% of the pasture area in the HRZ (Garden *et al.* 2000). Native pastures are much more common in NSW, where they dominate large parts of the landscape, than in Victoria, where they are said to occupy only 0.6% of the land area. At the industry level, differing views and confusion exist amongst producers and some scientists about the value of native species. In low-input systems, many producers have adopted rotational grazing strategies that appear to favour native perennial grasses; fertiliser rates, stocking rates, animal productivity per hectare and risk are low, but sustainability is perceived to be high.

While pasture legumes must be based on the locally adapted variants of exotic germplasm, there is a logical case for more use of management options that utilise adapted native grasses, and for the inclusion of a wider range of perennial grasses, particularly C_4 species, for pastoral use (Johnston *et al.*, 1999). Johnston *et al.* (1999) questioned the amount of research and development effort that has gone into replacing indigenous grasses with exotic introductions, many of which failed to persist over the frequent droughts that characterise the Australian climate. They reviewed the evidence for the persistence, productivity and nutritive value of several species of native grasses in grazed pastures, and argued for strategies that utilise adapted grasses such as wallaby grass (*Austrodanthonia* spp.) in high-input situations and red grass (*Bothriochloa* spp.) in low-input paddocks.

However, there is little hydrologic data upon which to base an hypothesis that native pastures, by depleting the soil of water by the end of summer, are any more or less efficient in controlling groundwater recharge than pastures based on introduced species. Indeed, lucerne seems without peer in its ability to extract more water, more quickly from soil profiles (Lolicato 2000), and phalaris is also effective. Another factor restricting the wider use of native grasses is the difficulty of producing, and the cost of, seed. Finally, there is a misconception (Johnston *et al.* 2001) that introduced perennial grasses are generally short-lived. As Scott *et al.* (2000) have noted, there are examples on the Northern Tablelands of NSW of well-adapted introduced species such as phalaris lasting for over 80 years and tall fescue for over 40 years.

Hence, as Johnston *et al.* (1999) acknowledged, there is folly in a “one-or-the-other” philosophy, compared with an approach that achieves complementarity between a low-input, conservative approach to pasture management and the high-input, exotic approach to pasture improvement that has produced notable gains in the productivity of Australian

agriculture. The survey participants acknowledged the complementarity of high- and low-input species and systems at both the regional and farm levels. Certainly, in the HRZ, there seems little point in ploughing or grazing out productive stands of persistent, perennial native grasses such as wallaby grass (*Danthonia* sp.) and weeping grass (*Microlaena stipoides*). In unproductive or unstable areas, native pastures might be usefully preserved. In areas of the WSZ, there is interest in the use of patches of native perennial grasses and shrubs to deal with dry land salinity, either by reducing groundwater recharge or tolerating discharge. The general view was that investment into the use and management of native species for pastures should represent between 10 and 20% of that into introduced species [see later].

Overview of pasture improvement in the WSZ (North West Slopes and Plains, Central West and Riverina in NSW; Mallee and Wimmera in Victoria; South East, Murray Lands and Yorke Peninsula, Eyre Peninsula in SA; North and East Wheat Belt, Central and South Wheat Belt in WA).

The selection/breeding of subterranean clover and annual medics has been the cornerstone of the pasture phase in the Australian WSZ since the 1940s. Facilities and resources were set up to assist the release of a range of cultivars of both species for different environments and soil types. The establishment of the National Subterranean Clover Improvement Program [funded by the Wheat Research Council and the Wool Research Trust Fund] in the late 1960s, and its extension in the early 1970s to include NSW and SA, gave an Australia-wide focus to the development of better-performing subterranean clovers. For the WSZ, important new varieties commercialised from the National Program, which had inputs from NSW and SA agronomists as well as from WA researchers, included Trikkala [adapted to soils prone to water logging], Nungarin [able to grow near the arid boundary of the WSZ], Dalkeith [a competitive and persistent early to mid-season cultivar] and Junee [a mid-season plant resistant to clover scorch].

During the 1980s, successful breeding efforts in annual medics and lucerne occurred in response to the outbreak of aphids that decimated stands of these legumes in the late 1970s. The lucerne recovery was rapid, due in part to availability and importation of aphid-resistant cultivars from the USA and other countries. Four lucerne breeding programs were active for a time; the remaining two, at Tamworth and Adelaide, have recently released cultivars that are demonstrably more persistent and productive than (1) the interim replacement varieties and (2) the original Hunter River strain. It took longer for the medic breeding program to provide a full array of aphid resistant cultivars. However, although researchers and advisers maintained that there were few good medic pastures evident on the soils that suit them in the WSZ, they all expressed a belief that current cultivars are as well as or better adapted than those available prior to the aphid problem.

In the 1990s, there was a rethink on the focus of plant improvement for the wheat/sheep zone. The National Annual Pasture Legume Improvement Program [NAPLIP, the co-ordinating body for annual legume improvement], decided to reduce inputs into subterranean clover and annual medic improvement, in favour of evaluating the potential of an array of annual legumes for the pasture phase of wheat/sheep farming systems. Several reasons justified the change in emphasis. A full range of subterranean clover and medic cultivars was available, and it was believed that further breeding might lead to only marginal improvements. In addition, there was a need to find species adapted to niches not suited to subterranean clover and annual medics, and to introduce new adaptive mechanisms not contained within these species. These mechanisms included greater adaptation to waterlogging, different patterns of hard seed breakdown, small seeds that can pass through the rumen undigested, aerial seeding for ease of harvesting and greater insect tolerance.

An early success was balansa clover (*T. michelianum*), introduced by SARDI for sites prone to intermittent waterlogging. Other studies and selection were concentrated on yellow serradella (*Ornithopus compressus*), which is adapted to the sandplain soils of WA and the Pilliga region in NSW, and French [pink] serradella (*Ornithopus sativus*), which produces easily harvested seed. In recent years, a lot of R&D has occurred with other annual legumes such as biserrula (*Biserrula pelicinus*) and gland clover (*Trifolium glandiferum*), and some perennial legumes such as sulla (*Hedysarum* spp.).

In WA, the change of emphasis of NAPLIP fortuitously preceded a recent reawakening of interest of farmers in pastures, a consequence of difficulties experienced in the wheat/lupin rotation and in controlling herbicide-resistant weeds, as well as improved livestock prices. Benefits such as cheap seed resulted in the rapid adoption of those new legumes, such as balansa clover and French serradella, that were seen by farmers to perform well during the pasture phase of the system. For example, Cadiz, a soft-seeded cultivar of French serradella, is easily harvested by conventional machinery and suited for grazing or as a green manure crop; it is already grown on 300,000 ha of predominantly sand plain soils north of Perth, and this area is expected to rise to 500,000 ha in 2002.

The arable areas of SA share with WA a similar short phase pasture/crop farming system. Many of the new legume genotypes may prove to be as useful there as balansa clover, while Cadiz pink serradella has found a niche in the south-east of SA. However, neither of the serradellas nor biserrula is at home on soils with free limestone, which occur widely in SA. So far, these genotypes have not made an impact, perhaps due to lack of testing and to some of the special problems that pertain to pasture legumes in the alkaline Mallee soils of SA and Victoria. These problems will be outlined in the section on the Mallee region.

In NSW, subterranean clover (acid soils), lucerne (most wheat belt soils), medics (alkaline pockets), balansa clover (soils prone to intermittent waterlogging) and yellow serradella (acid, sandy soils of the Pilliga region) are well entrenched, and are performing satisfactorily. Indeed, seed sales of lucerne have increased by up to 10-fold in certain districts on the NSW Slopes and Plains. The new wave of legumes is yet to have an impact on these farming systems and on red meat production. However, there has been sufficient R&D activity, on the southern and central slopes and plains particularly, to establish the interest of growers in the new legume genotypes and in the agronomic package that goes with each. Forage legumes that can be grown as a crop in the rotation, to clean up weeds and conserve soil nitrogen, are also of interest.

With the exception of the Northern Slopes and Plains of NSW, there is no area of the wheat/sheep zone belt where there has yet been a significant impact of improved grasses. Grasses are, of course, either a potential weed in the cropping phase and/or a sink for nitrogen. However, there is some reassessment of their role, particularly with respect to dryland salinity. This reassessment is constrained, at least in part, by competition rather than collaboration between researchers, involving IP issues [e.g. researchers in one NSW department were unwilling to supply seed samples for experimental use by their colleagues in another department] and agricultural and environmental imperatives.

The North West Slopes and Plains of NSW: a special case

The North West Slopes and Plains of NSW contain 4.3 m sheep and 1.0 m beef cattle. The region is characterised by a summer-dominant pattern of rainfall (varying between 600 and 750 mm), which is not suited to the production and conservation of seed from winter annual legumes and is too dry for white clover. While annual medics regenerate well in some seasons, the predominant pasture legume is lucerne, which is well adapted to the soils and environment of the arable NW Plains. The lucerne breeding program at

Tamworth has targeted a range of fungal pathogens that affect the lucerne crown and root system, and good progress has apparently been made in improving lucerne persistence. However, the area of lucerne is constrained by the attitudes of the farmers, many of whom are crop farmers rather than livestock producers. In this mainly beef cattle area, producers are also concerned with the bloating potential of lucerne. Sulla (*Hedysarum* spp.) has performed well on alkaline, heavy clay soils and it may turn out to be a bloat-free legume that is complementary to lucerne on the Northern Slopes and Plains, especially for producing cattle feed for winter.

The terrain and soils of the non-arable grazing lands, most of which are cleared of timber, are not suitable for lucerne and probably not for sulla. Although pigeon pea and bambatsi panic are apparently well adapted to the conditions, other suitable pasture species are needed, especially a drought-tolerant, prostrate to semi-erect perennial legume, of temperate or subtropical origin. Subtropical grasses are also required for the Northern Slopes and Plains - to produce feed, control weedy grasses, and reduce surface water flow, erosion and recharge.

The network of pasture research agronomists in this region, with its wide range of soil types and variable climate, is comparatively less well-developed than in southern NSW. It is also acknowledged within NAPLIP that the testing of temperate and subtropical legumes is under-resourced in this region and adjacent areas in southern Queensland. There is considerable grower interest in C_4 grasses and the availability of seed has increased in recent years. Some major problems have occurred with the establishment and management of these grasses, and the solutions to these problems are not yet clear.

The Mallee regions of SA and Victoria; some problems for pastures

The sheep population (1999-2000) of the Mallee lands is 1.5 m (Victoria), 4.0 m (Murray Lands and Yorke Peninsula), and 1.8 m (Eyre Peninsula); the corresponding numbers of beef cattle are 38,000, 100,000 and 34,000, respectively. On this basis, the Mallee lands are significant producers of red meat; however, our assessment revealed that not only lower rainfall but also producer practices limit productivity.

Up to the late 1970s, improved pastures were sown with annual medics. The cultivars of medic released during the 1980s (Sephi, Parragio, Mogul) and 1990s (Caliph, Herald, Jester and Toreador) are regarded by farmers and their advisers as the agronomic equal of the old aphid-susceptible cultivars (Jemalong, Borung, Hannaford, Harbinger and Cyprus). However, pasture surveys undertaken in the early 1980s (Carter 1982), the early 1990s (Rigby and Latta 1995) [see Table 2], and in 2000 (Robertson, 2000) have indicated that the actual on-farm performance of medics is less than satisfactory.

Table 2: Survey of medic pastures in 1993/94 (Rigby and Latta 1995)

Proportion of sites surveyed in:	Medic density class		
	Deficient (>50 plants/m^{-2})	Marginal (50-200 plants/m^{-2})	Acceptable (>200 plants/m^{-2})
Central and S. Mallee, VIC	76%	13%	11%
South-west NSW	60%	20%	20%

Murray Mallee, SA	67%	8%	25%

Surveys and observations by Robertson (2000, and ongoing) and Latta (2002) have pointed to a probable 10-fold variation in the legume productivity of „medic" pastures, depending on the level of pasture management. At the low end, there are volunteer pastures that comprise part of the fallow phase between crops in pasture-crop and pasture-pasture-crop rotations. At the high end are pastures on 10-20% of farms, where farmers have made a conscious effort to sow and manage their medic pastures as a crop.

We therefore conclude that the main factor responsible for the difference between the best and worst pastures is management. We believe that many producers either do not see a need for pasture improvement or their fallow/crop system promotes the continuation of unproductive volunteer pastures. With two exceptions, there is no obvious technical constraint to better medic pastures. The first exception is a need for benchmarking the productivity of pastures and sheep, to show what can be done. The second impediment is a general concern that some medic pastures may be constrained by residues of sulfonyl-urea herbicides used on wheat; this may be overcome by the commercialisation of a strain of medic resistant to the herbicide.

In terms of alternative pasture species, in Victoria and SA an enthusiastic minority (5-10 %) of mallee farmers/graziers use a short-phase pasture phase comprising a mixture of vetch (predominantly *Vicia saliva*, cvv. Blanchefleur, Morava and Haymaker) and CCN-resistant cultivars of oats. Vetch is popular because farmers can harvest and sow their own seed, which establishes readily. Another small group of farmers (2%) uses lucerne, which is promoted on the grounds of productivity and sustainability. However, most farmers do not like taking their country out of crop for a lucerne phase. In addition, many mallee soils, such as those in the southern Mallee area of Victoria, have subsoils that contain high quantities of sodium and boron (Rengasamy 2002); lucerne failures are common on these soils.

In summary, the current constraints to pasture improvement for red meat production from the Mallee areas include farmer apathy toward pastures and livestock compared with crops; an apparently higher level of satisfaction of farmers compared with scientists about the performance of medic pastures; the lack of an effective extension input into pasturemanagement in central and northern Victoria; and a possible effect of residual herbicides on the root development of pasture species.

Impact of pastures on red meat production

The use of fertiliser to overcome the low fertility of soils in the HRZ and WSZ of Australia, coupled with the introduction of responsive pasture grasses and legumes, was the cornerstone of the sheep and beef cattle industries of temperate Australia during the latter half of the 20th century. A recent reawakening of interest in the conservation of native species and pastures is a development that, in a community sense, is complementary to high input production.

Since 1990, new cultivars of perennial grasses and legumes have had a relatively small impact on red meat production in much of the HRZ (but see under ***MLA investment in pasture improvement*** [pp 30-32]. However, in the WSZ and in other parts of the HRZ, there can be no doubt of the fundamental importance for pasture output of the cultivars of subterranean clover, annual medic and lucerne released from the ongoing selection and

breeding programs. These pasture legume cultivars have been responsible for much of the pasture improvement impact that has occurred during the past decade. In addition, the recent success of Paradarna balansa clover and Cadiz pink serradella has illustrated the potential of new species and varieties to fill specific niches. Impacts arising from the release of other „new" legumes, available during the past few years, are just beginning to be apparent. It is almost certain that the positive effects of these new plants and the others to be commercialised within the next few years [see later], will be demonstrated in large measure in the next decade.

The nature and extent of the benefits to their livestock enterprises, which groups of red meat producers are finding, depends on the chosen baseline against which their productivity gains are compared. Such benefits include improvements to the nutritive value of pasture species (for example, through a low content of formononetin in subterranean clover herbage), better persistence, enhanced pest and disease resistance, improved adaptation to specific niches, and the increased availability and lower cost of seed.

Recent developments with serradella and new directions in the search for a broader array of perennial legumes, are also likely to produce environmental benefits, such as improved water use efficiency [WUE], leading to lower groundwater recharge, as well as improved productivity. The beneficial effects of lucerne in reducing the ravages of salinity are being widely accepted by farmers. Already there are more than 500 WA lucerne growers. Salinity is the new driver of change in the plant improvement program. The search is now on for suitable perennial legumes such as sulla [*Hedysarum*], *Lotus* spp. and *Dorycnium* spp., which may be persistent in WA and southern Australian environments. Each of these species, if introduced, will require a management package to guide graziers in the best use of the new genotypes. Experience has shown that producers can add value to these packages. Industry also can make much greater use of the overall pasture management tools that are available in the form of modelling packages such as GrassGro and pasture monitoring protocols such as PROGRAZE

Finally, it is necessary to mention the importance of the current work of the *Rhizobium* network, now directed from a Centre at Murdoch University established by Howieson and his colleagues. This network is an integral component of the development and commercialisation of new legumes. Rhizobial testing has revealed big differences in the effectiveness of *Rhizobium* strains for assisting the growth of new legumes. Ineffective strains are rapidly replaced. For example, a number of recently identified strains increased yield in *Lotus* by more than 200%. Associated ecological studies undertaken on the taxonomy, growth and survival of *Rhizobium* are necessary both to improve understanding of the bacteria and predict their field performance.

° While most red meat industries in southern Australia are in either the HRZ or the WSZ, significant numbers of sheep and cattle are also found in two other distinctive areas, namely the NW Slopes and Plains of NSW and the Mallee regions of SA and Victoria

° Most of the animal output is produced on high input pastures, though recently, coinciding with an increasing focus on conservation issues, there has been some mild interest, especially in the HRZ, in low input systems based on native grasses

° Negative farmer attitudes to pastures and a limited extension network are major factors in the low levels of animal production which generally characterise the NW Slopes and the Mallee regions

° During the past decade, the availability of new pasture plants [especially legumes], has been an important factor in raising pasture productivity in much of the WSZ. Most such

plants have been cultivars of subterranean clover, annual medics and lucerne. However, the first releases in an array of annual legumes, now being selected for the pasture phase of the rotation, are beginning to have an impact, with one plant, pink serradella, cv Cadiz, being sown on 300,000 ha in 2001

° New pasture plants have had a relatively small impact on red meat production in much of the HRZ. There, management, reflected in continuing use of superphosphate, with strategic dressings of lime in southern NSW, together with moderate to high stocking rates, has been the key factor in determining pasture output.

MLA investment in pasture improvement

For reasons already stated [p 18], it is too soon to make a comprehensive assessment of the impact of MLA investments on pasture plant improvement; this would require benefit:cost analyses to be made over a period of time, a recommendation made earlier [p 18]. The majority opinion of review participants agreed with our conclusion of a limited impact, so far, of new cultivars in improving pasture output in the HRZ, the focus of most MLA investment in pasture plant improvement. However, a number of improved cultivars developed in the MLA-supported work in Vic and SA are already being adopted widely by farmers and graziers, especially those with more intensive pastoral enterprises. While most improved plants are replacing older varieties, some are being sown in new areas.

This clearly points to the value placed on these improved cultivars by these producers, and, by inference, on the MLA investment in their development. Further, a number of those interviewed, including several producers associated with the MLA-supported programs undertaken by DNRE and SARDI, felt strongly that (i) new cultivars developed in such work had been an essential component of the increased output which they had achieved on their intensively managed pastures, and (ii) were needed to obtain high yields from such pastures. We feel sure that this need will increase with the greater adoption of improved cultivars. We are also confident that these industry benefits from the products of MLA investments, already clear to a number of producers, will become more widely apparent in the next few years.

Past MLA support for the development of better plants has resulted in a number of results that can be built on to provide opportunities for future company investment in pasture improvement. These opportunities will be discussed further in developing and recommending a strategy for such future MLA investment.

In spite of MLA"s considerable support of pasture plant improvement during the past decade, the extent, and even knowledge, of the Company"s contribution to pasture plant improvement seem barely appreciated outside the group of scientists who have worked on the projects supported by the Company. Even the contribution of MLA to projects which received high praise for the contributions they have made to better understanding, and improving the level, of pasture management, such as SGS and PROGRAZE, was not widely known. Whilst extension workers, consultants, some administrators and research agronomists were aware of the support provided by the Company to these programs, relatively few farmers and graziers contributing to the survey seemed to know of the contributions which MLA had made, and continues to make. For example, the primary producer members of the central committee of the Grassland Society of Victoria had “very limited awareness of MLA projects”. The comments of the Secretary of the Society, namely - “I suspect that had a list of projects funded by MLA been included then the farmers could have commented on their contribution or significance” are very telling.

Clearly MLA has not done enough to develop a significant profile with its primary producer stakeholders The Company has undersold its support and achievements in helping to improve pasture output. Repairing this deficiency must present both a challenge and a real opportunity in formulating MLA"s future priorities.

No seed company executive interviewed professed any knowledge of the MLA Donor Company. However, we learnt later that one company, the Chief Executive of which participated in the review, had two projects at an advanced stage of discussion for support from the Donor Company.

Recommendations

MLA should take such measures as are necessary to demonstrate to its stakeholders, especially red meat producers, the contribution it has made, and continues to make, to improving pasture productivity

MLA promote the existence of its Donor Company and the opportunities it provides to assist funding for plant improvement

S***ummary***

° The majority view of survey participants coincides with our conclusion that improved cultivars from MLA-supported projects have had a relatively small overall impact, so far, on pasture improvement in the HRZ

° A number of people expressed a different view, pointing to the need for, and value of, new varieties in achieving high output from intensively managed pastures

° Though overall industry benefits of MLA investments in pasture plant improvement have been relatively small so far, some producers have already obtained significant gains; further benefits will accrue as new cultivars from supported projects become more widely adopted

Factors affecting pasture output in southern Australia

The interviews and responses to our questionnaires showed that, since 1990, improved pasture plants [particularly in the WSZ], management, systems studies and the transfer of research findings have all played a significant part in the improvement of pasture output that has occurred in southern Australia. The contribution of each of these components to the red meat industries is discussed in this section.

Improved pasture plants

Selection, breeding and evaluation

The early high input Australian pastures were based on improved plants which were normally selected, either from populations that had become adapted to the prevailing growing conditions [ecotypes], or directly from introductions. They included many of the early varieties of phalaris, subterranean clover, the annual medics and lucerne. Selection is also the main method being used to develop cultivars of the new legumes and a number of grasses originating from Mediterranean environments. Such selections, generally the first stage in plant improvement, often resulted in greater increases in pasture output than the cultivars which subsequently replaced these early varieties.

Breeding, involving crossing of potential parent plants and evaluating the progeny of these crosses, is usually the second phase in the improvement of a pasture plant in Australia. For example, whereas the first improved lines of subterranean clover were the result of selection, breeding has been employed in the delivery of low formononetin cultivars, as well as of many of those with differing lengths of maturity, adaptation to specific soil types and resistance to a number of pests and diseases. A similar situation obtains in the development of improved
cultivars of lucerne, phalaris, annual medics, perennial ryegrass, white clover and tall fescue.

Credible evaluation of a cultivar prior to its release is important in defining its adaptive range. Performance testing, normally undertaken in target areas, usually consists of measuring seasonal and total annual DM production over a period of three years [for perennial species] and shorter periods for annuals and biennials. Sometimes the plots are grazed but more frequently they are cut. Additional information, e.g. on adaptation to specific rainfall and soil conditions, and degree of resistance to particular pests and diseases, is normally included in the information available to the purchaser.

Benefits from pasture plant improvement

In southern Australia, pasture plant improvement has resulted in the provision of germplasm able to grow under a number of climatic and soil constraints, e.g. moisture stress, high and low pH, waterlogging and salinity. The continuing stream of new species and cultivars, which has become available commercially since the 1950s, has considerably increased the area where productive pastures can be grown. These improved plants have also widened the options for animal production and provided a means to resolve some of the sustainability resource problems [e.g. erosion, deep drainage and salinity] confronting meat producers, thereby also enabling some environmental issues to be addressed.

Most of the improvements in introduced pasture plants, expressed in a range of plant traits and which have resulted in higher stocking rates, greater animal output [per head and per hectare] and increased farm income, have been detailed earlier [p 22-25]. The development of high quality herbs, such as chicory and plantain, was also recognised by several participants as a real benefit for specialist lamb producers.

A number of plants deserve special mention because of their contribution to both productivity and the amelioration of environmental problems. Amongst these, lucerne, particularly the new cultivars, not only provides highly nutritive feed, especially important for producing quality meat in the wheat/sheep zone, but its deep root system can use more water, thus reducing groundwater recharge and ameliorating salinity. It is hardly surprising that the use of lucerne has increased considerably during the past few years, particularly in the wheat/sheep zone. Perennial grasses are also significant in combating environmental degradation. They are better able to provide complete ground cover than are annuals, thus reducing the risk of erosion. There is no doubt that as environmental issues become more widely appreciated, quantification of the effects of specific plants, as well as of pastoral systems, on the environment, will become increasingly common.

Some benefits to pastoral industries

The benefits flowing from improved pasture cultivars have probably been potentially greater for meat [and wool] producers than for dairying, because red meat production is spread over a much wider range of rainfall and soil conditions. However, there is evidence that the degree of benefit depends on the product, e.g. novel ryegrass endophytes are of most benefit to the sheep and beef industries. Whilst new white clover cultivars have more

widespread benefits, those with small leaves are best adapted to set stocking of sheep and rotationally grazed pastures for sheep and beef, in contrast to the larger leaved cultivars, which suit rotationally grazed dairy systems.

Problems associated with the use of improved plants

Most survey participants who commented, nominated the most common problem of using introduced pasture plants as their failure to persist. Poor pasture establishment and dying out of desirable species results in weed invasion and, often, a sward with a high proportion of annuals. This, in turn, leads to a more open, less stable pasture, prone to soil erosion. Further, poor use of summer rainfall by short-lived annuals results in increased water recharge and soil salinity. In some catchments, removal of trees, a practice frequently associated with pasture improvement, causes impaired hydrology and salinity.

Introductions are not suited to some soils, e.g. sodic soils in SA and western Victoria, most are poorly adapted to waterlogging, whilst a number of legumes are very susceptible to pests such as the flea beetle and red-legged earth mite. Other problems associated with the use of improved plants, such as bloat in cattle on legume-rich pastures, and rapid death of sheep grazing phalaris, remain. Yet neither these, nor others such as the build-up of grubs, apparently implicated in Eucalyptus die back, or the recent interest in native pastures, as alternatives to improved pastures, have dimmed the overall enthusiasm of producers for basing their swards on exotic species.

Contribution of pasture plants to pasture productivity

It is stating the obvious to say that pasture plants are the first essential in determining pasture output. In the absence of plants that are able to persist and produce high yields of good quality feed under the growing conditions prevailing, there is little hope of achieving a high level of sustainable production. The impact of delivering improved plants - whether new species or improved cultivars - thus depends to a large extent on whether or not good pasture plants are already part of the pastoral enterprise under consideration. If a new plant, able to persist and provide high yields of quality feed, is introduced into a region where no such plant had been available previously, big gains in animal production and net farm income can be anticipated.

A graphic illustration of this has been provided by Chapman [pers comm]. An experiment

Table 3 Effects of management inputs on pasture productivity and gross margin, SGS National Experiment site at Vasey, western Victoria. Values are means 1997-1999. Pastures were grazed by spring-lambing merino ewes, stocking rate adjusted 2-3 times per year depending on animal live weight and pasture mass [Chapman, pers comm].

Treatment	Lamb production - kg/ha^{-1}	Estimated gross margin - $/ha
Unimproved pasture[1] -low P[3]	145	54
Improved pasture[2] - low P	352	225
Improved pasture - high P[4]	425	241
Improved pasture - high P + rotational grazing	443	248

[1] dominated by barley grass, silver grass, soft brome and onion grass [2] sown to Australian phalaris and Trikkala subterranean clover - 1994 [3] average 8 kg P/ha^{-1} [4] average 25 kg P/ha^{-1}

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undertaken at the SGS national site at Vasey, western Victoria, [625 mm annual rainfall] incorporated a comparison of the incremental effects on animal production and net farm income of [i] resowing a pasture dominated by unproductive perennial grasses with an adapted perennial grass [phalaris] and a legume [subterranean clover], [ii] increased fertiliser application, and [iii]improved grazing control. As can be seen from Table 3, the biggest

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effect came from the responsive plants which were introduced into the system. Whereas both improved and unimproved pastures produced a similar level of DM production, the herbage quality on swards comprising exotic species was vastly superior to that on unimproved pasture. Increased fertiliser resulted in significant but relatively small production increases, with even smaller increases from rotational grazing.

Effects of management on pasture productivity

If high producing cultivars are present to provide the pasture feed base, relatively small additional gains can normally be expected following the use of a new cultivar. In such circumstances, pasture management [particularly establishment or renovation, and fertiliser and grazing regimes], becomes the major factor in determining the levels of quality forage produced.

In the establishment or renovation of improved pastures, sufficient sown plants are needed to produce a complete ground cover. If this objective is not achieved, adverse consequences for both pasture sustainability and the environment, similar to the effects of overgrazing described below, are likely to follow.

Superphosphate can both affect botanical composition during pasture development [e.g. Wolfe and Lazenby, 1973 a, b] and reduce the rate of pasture degeneration [e.g. Cook *et al*., 1978a, b]. Under low fertility conditions, there is evidence that P increases the productivity of a potentially high yielding sward more than an improved cultivar. For example, NZ work showed the increase in pasture productivity resulting from the application of P was 2.5 to 3 times greater than by the introduction of the improved white clover cultivar, Tahora [Chapman *et al.*, 1993]. Thus, the cultivar was no substitute for the fertiliser However, it did improve the return in a difficult environment. It must also be remembered that new seed, like that of establishment, is a one-off cost spread over the life of a pasture, whereas fertilisers are an annual expense.

Grazing management can have a considerable influence on both pasture establishment and the botanical composition of the sward. Selecting the appropriate stocking rate is all important in the utilisation of herbage, and hence a vital factor in determining animal output and farm income [see later]. Both undergrazing and overgrazing are deleterious. Whereas the former results in poor utilisation of the pasture and makes its management more difficult, the effects of overstocking are even more damaging in the long term. The reduction in the proportion of desirable perennials, an increase in the content of annuals and weeds, and in the bare ground, the consequences of overgrazing, lead to reduced pasture sustainability and greater environmental degradation. Such degradation can include reduced water use, increased salinity, soil erosion and pollution of rivers and catchments.

A recent study [Vere *et al.*, in press] has shown annual opportunity costs for lamb production resulting from weeds in temperate pasture systems in NSW and Victoria to be between $50 and $133m, with costs caused by serrated tussock much greater than those for other weeds. A 15 year benefit:cost analysis indicates benefits from reducing the impacts of all pasture weeds to between some $130 and $420m in lamb production.

Two other aspects of management, namely the placement of fences and the siting of water access are both capable of influencing productivity.

Pasture/animal systems and technology transfer

The past decade has seen a fundamental change in our thinking with the wider appreciation of the need to study pasture output as part of an integrated whole, with all the factors potentially limiting productivity incorporated in the system. A number of projects and programs, based on such systems, has been responsible for increasing the producers' awareness of factors important in managing their pastures and stock and, therefore have provided the basis of better management decisions. They have also helped effect a remarkable change in the attitude of many producers towards increasing their knowledge on factors affecting pasture output, with a number volunteering that they actively sought, and attended, courses to learn more about maximising their profit.

There was almost universal appreciation of the value of certain experiments and extension programs. Taken together, they show [i] the roles of modelling, extension methods, consultants and agronomists in increasing output and in transferring technology, and [ii] the need to involve farmers and graziers in the activities. Some enable decisions to be made for specific on-farm conditions rather than accepting generalised recommendations. Others enable producers to benchmark their performance against that of other participants.

A number of activities deserve a brief description to illustrate both the differing objectives and impact of such projects. One, the Hamilton Long-Term Phosphate Experiment was established in 1977, when perennial ryegrass, phalaris and subterranean clover were sown on land, typical of large areas of basaltic plains soils, with a low fertiliser history and a mean annual rainfall of some 700 mm. The six phosphate treatments ranged from an average of 1 to 33 kg P ha^{-1} $yr.^{-1}$ with the increased P-status, [up to 17 kg P ha^{-1} yr^{-1}] having a considerable effect - thought remarkable in the 1980s and early 1990s - on pasture yield and quality, stocking rates, animal production and gross margins. Visited by many hundreds of people from all over Australia, the experiment demonstrated the potential of a high input system. It "has had a huge impact on the grazing industries in the high rainfall areas of south-eastern Australia" [Sale, 1999].

The Grassland's Productivity Program was initiated in 1993 by the Grassland Society of Victoria to help pastoral producers develop their skills and gain confidence in their ability to manage productive pastures. It involved the establishment of a number of groups of 4 - 6 farmers across south-eastern Australia with each participant making a paired paddock comparison of the then current practice of pasture management with productive pasture technology. The Program ran for three growing seasons and, in 1995, some 200 farmers from SA, NSW, Victoria and Tasmania were involved. The financial performance of those participating was markedly superior to non-participating farmers. Major changes in management practice were also recorded, with participants increasing their P applications and stocking rate by an average of more than 100% and 30% respectively after the completion of the Program.

The Sustainable Grazing Systems (SGS), a comprehensive 5-year program embracing productivity, profitability, sustainability and social issues, was set up in 1996. It was the

result of an initiative by MLA [which managed the program], and was also given substantial support by a number of other organisations and bodies. Its goal was to have at least 2000 producers in the HRZ of southern Australia adopt changes resulting in their grazing systems becoming at least 10% more profitable and sustainable, with a further 5000 producers having trialled some of the recommendations. SGS had 4 inter-related activities, namely : PROGRAZE [to train producers and develop their skills - see below]; Regional Producer Networks [based on regional committees which determined priority issues and managed local delivery]; a National Experiment [to develop principles, tools and indicators for improving profitability and sustainability]; and, Integration and Management [to ensure that the goal was met effectively and efficiently].

An assessment of SGS, undertaken by ABARE, showed the goal of the project to have been more than met. Over 40% of producers in the HRZ zone [approaching 10,000] had been associated in one way or another with the project and more than 60% knew of its existence. Over 8,000 producers had changed their grazing practices, with some 80% confident that such changes would result in increased profit and/or sustainability. Better pasture and animal management, increased recognition and understanding of environmental issues, and greater likelihood of adoption of best practice were other benefits from SGS, which also resulted in helping producers share information with others.

Not surprisingly, SGS generally received high praise from review participants. Although some producers were critical of the value of a number of sites, others e.g. at Vasey, Broadford and Lucindale were said „to be excellent". There was also some feeling that the 3-year duration of the project was insufficient to provide worthwhile information on sustainability. However, there can be no doubt that SGS provided an excellent avenue for communicating with farmers and graziers and was very significant in catalysing improved grazing system management.

PROGRAZE, a management support program for a range of pastoral enterprises, developed initially by NSW Ag, and subsequently supported by MLA, for decision making at the individual farm level, won widespread plaudits from all those associated with it. One leading administrator described it as the delivery mechanism for SGS, whilst a research leader labelled it as „a wonderful project built on research and aimed at making decisions for profit". More than 8,500 producers have attended PROGRAZE courses, acquiring skills in managing pasture plants and animals, thus equipping them to make better decisions. The identification of key profit drivers - the right pasture plants, coupled with a series of management decisions on the fertiliser regime, stocking rate, time of joining, Helminth control and supplementary feeding - is an essential part of the model. A component of PROGRAZE, GrazFeed, is a tactical decision-making tool, developed by CSIRO and based on more efficient use of supplements. Better decisions about animal nutrition using GrazFeed have been estimated by NSW Ag to return at least $7.5m per year in the State for the sheep industry alone.

A further management support tool, GrassGro, also developed by CSIRO, takes decision-making a step further. Based on models enabling the assessment of how weather and soils combine to affect pasture productivity and profitability of single pasture systems, producers can use GrassGro for a range of pasture-based animal industries to help determine risks and estimate profits, in both short- and long-term. Effects of: varying stocking rates on gross margins; year-to-year variability in feed supply; and changing joining and weaning dates, e.g. to supply meat when required by the market, can all be predicted. Further, potential new methods can be tested before committing resources to any possible changes in the system.

The Farm Monitor Project, originally set up in the Hamilton district and extended in 1986-87 to include farms throughout SW Victoria has had an average of about 50 participants. Whilst the aims of the project include monitoring trends in farm productivity, its greatest value comes from provision of benchmarks and data to evaluate the differences between top performers and other participants. Considerable improvements in productivity have been achieved, especially by the top 20% of participants. Not only do they have a gross income of some 25% greater than the mean of those involved, but they have calculated that their optimum SR should increase by 1.3 DSE ha^{-1} for every extra 25 mm of annual rainfall above 250 mm.

Summary

° Improved plants, pasture management, systems studies and the transfer of research findings all have an important role in improving pasture productivity.

° Whilst the initial increases in pasture output are normally the result of introducing new plants, appropriate fertiliser and grazing policies are then needed to produce and utilise the herbage produced.

° Since 1990, major improvements in animal output and farm income from improved pastures in southern Australia have flowed from systems studies and the transfer of research findings, in which researchers, extension workers, consultants and producers have all played a part

° Examples of research/extension projects that have catalysed changes in management practice in the past decade have been briefly summarised

The changing scene for pasture plant improvement

Prior to responding to Project Objective 2, it is pertinent to [i] consider the changes which have occurred in pasture plant improvement programs in Australasia during the past decade, particularly in the public sector, and [ii] compare the likely productivity gains from conventional breeding and biotechnology. The results of such considerations not only bear on our response to Objective 2, but they also provide information on constraints and opportunities needed in responding to Project Objective 4.

Plant breeding in 1990

In 1990, pasture plant improvement in Australia and New Zealand was vested very largely in the public sector, i.e. in state and federal governments and in universities, all of which were then funded very largely by public investment. Responsibility for the public funding of such activities was widely accepted, and a range of organisations including government [both State, through their Departments of Agriculture, and Federal, through CSIRO], and universities had their own breeding programs. A number of R & D Corporations [AWI, DRDC, GRDC, MRC and RIRDC] were either then supporting public improvement or would soon do so. This support, while important in assisting the achievement of specific objectives, was not critical to public pasture plant improvement programs at that time.

Levels of public funding were sufficient for the establishment and continuing viability of such improvement in every state in Australia, ACT and in New Zealand. Further, the plant breeders had access to the necessary specialist support required to better understand and control serious limitations to pasture plant performance e.g. pests and diseases. The total level of expertise available for public sector breeding was thus sufficient to respond rapidly

to serious problems. For example, following the devastation of lucerne by aphids in 1977, at least four public programs attempted to develop cultivars resistant to aphid attack.

The focus of individual improvement programs broadly reflected the perceived responsibilities and interests of the bodies involved, sometimes influenced by historical decisions and by early staff appointments e.g. the Canberra CSIRO phalaris improvement program. Improved plants were released as unprotected public varieties and marketed widely by seed companies supplying retail outlets throughout Australia and New Zealand.

The changing environment

The setting up of a procedure by the National Pasture Improvement Co-ordinating Committee [NPICC] (a subcommittee of the Standing Committee on Agriculture [SCA]) in the mid-1990s resulted in the establishment of a priority list of problems in important temperate perennial pasture plants. Funding, particularly that of R & D Corporations supporting improvement in such plants, became restricted to these priorities; it became increasingly important, in both sharpening the focus of breeding effort in public programs and contributing to their rationalisation.
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Yet the dramatic changes which have occurred in pasture plant improvement in Australasia during the past decade, were largely the result of a series of other decisions and developments that occurred within this period. Changed attitudes to the roles and funding of public bodies, and ensuing changes in their structure; the increasing use of biotechnology, with its potential for „quantum" improvements in pasture plant performance; the globalisation of many seed companies and their increasing dependence on proprietary cultivars [see later]; and the rapidly growing significance of Intellectual Property [IP], have all combined to produce considerable change in the circumstances for plant improvement.

During the past decade, funding for public breeding has been reduced considerably, with breeding programs becoming much more reliant on outside funding for their continuing survival; alliances have been formed between public breeding programs and outside funding bodies, including seed companies, responsible for commercialising improved cultivars; management structures have been established to protect the interests of those contributing to specific projects e.g. to influence the selection criteria, monitor the progress of the work in achieving agreed targets and determine the shares of royalties from sales of the proprietary cultivars produced.

The reduction in public investment in pasture plant improvement within Australasia has been uneven. The biggest withdrawal of support has occurred in New Zealand, which is no longer involved directly in plant breeding. Improved genetic material is sold, under agreement, to seed companies and, while some breeding is undertaken under contract for private companies, the prevailing NZ philosophy is to „leave breeding to the private sector". Considerable effort is put into research to better understand and control important problem areas, such as endophytes in ryegrass, whilst work on biotechnology, to provide an additional tool available for developing improved cultivars, also has a high priority. Biodiversity in temperate perennial grasses and legumes, available for Australasian pasture improvement programs, is maintained in the Margot Forde Forage Germplasm Centre at Palmerston North.

Until recently, Victoria had a large public breeding capacity [sited at the PVI, Hamilton] primarily for improving perennial ryegrass and white clover. Following two reviews, the first [Economic review of the returns to Victoria from Victorian-based pasture plant breeding projects]undertaken by Bennetton and Appleyard (1997) [DNRE] and the second [Future

directions for plant breeding for the dairy industry of Australia], by Fennessy and Barlow (2001), commissioned jointly by DRDC and DNRE, the responsibility for much of the pasture plant breeding in Victoria has been largely devolved from the public to the private sector. Biotechnology now assumes a much enhanced profile. Other work is focused on the better understanding of a number of areas of opportunity, including increased out of season growth and improved quality, seen presently as important limitations to cultivar potential. Priorities for research funding have been agreed between DNRE and DRDC, with both parties pooling their resources to achieve defined objectives. Victoria has the biggest concentration of biotechnologists engaged in pasture plant research in Australia [The La Trobe Plant Biotechnology Centre], and this Centre and the PVI improvement program at Hamilton are both included in the CRC for Molecular Breeding. A sizeable collection of germ plasm, particularly of perennial grasses, is maintained at the PVI.

Support for public breeding in NSW is concentrated largely on two legumes, namely lucerne, with a successful program centred at Tamworth, and white clover, developing cultivars for dryland beef/sheep environments, at Glen Innes. Support is also provided at Wagga for the evaluation of cultivars of subterranean clover and other legumes developed under the NAPLIP Program. Public funds for the programs are augmented by support from other bodies. GRDC contributes to the funding of the lucerne breeding, with new varieties being commercialised by Seedco, whilst the white clover work enjoys expertise from New Zealand AgResearch and has commercial links with AgriCom [New Zealand] Ltd and Pacific Seeds Ltd, whilst the evaluation of annual legumes is part of the NAPLIP program supported by GRDC and AWI. Selection of improved native grasses has also occurred, at Tamworth (*Danthonia*) and at the University of New England (*Microlaena*). This latter program has been funded in large measure by MLA; indeed, the work could not have proceeded in the absence of this support.

Whilst South Australia relies on varieties of ryegrass and white clover bred in New Zealand and Victoria, the state government funds a successful lucerne breeding program in which it continues to invest. The work has also received generous support from MLA, some funding from DRDC and a financial contribution from the former AWI. Strong links have been developed with Heritage Seeds Pty Ltd; the company has had a significant influence on selection criteria [the high seed yield of the soon to be released Super Ten is one example] as well as contributing market expertise in developing sales strategies. The SARDI program illustrates the important principle that, in any such joint venture, seed companies should be involved from the beginning of the breeding program wherever possible. [Other lucerne improvement being undertaken by SARDI, includes a project focused on Western Australia, which is supported significantly by GRDC, and another on China, assisted by ACIAR]. The biodiversity centre for annual medics, lucerne and related species is centred in Adelaide and has been built up to some 37,500 collections covering 159 different genera and some 731 species. Whilst annuals comprise the majority of the collections, an increasing number of perennials [now nearing 5,000] have been acquired in recent years.

In Western Australia, public breeding is still reasonably well funded, with the state government, the University of Western Australia and CSIRO all contributing to an integrated program. Historically, most effort has been focused on improving subterranean clover and the annual medics, with achievements in improving subterranean clover, both before and since establishment of the National Subterranean Clover Improvement Program, being widely recognised. However, the Centre for Legumes in Mediterranean Agriculture [CLIMA] and, more recently, the CRC for Plant-Based Management of Dryland Salinity have changed the focus of pasture plant improvement in the State. It is now based mainly on a search for new plants, largely legumes, for pastures in environments not suited to subterranean clover and annual medics, and for deep rooted perennials to slow or prevent soil salinity. Such areas form major tracts of the wheat/sheep zone. Agriculture WA is responsible for

maintaining the germ plasm for subterranean clover and the new legumes, whilst there is a comprehensive collection of strains of rhizobia at Murdoch University, with Professor Howieson having responsibility for coordinating rhizobial research, strain testing and quality control.

In Tasmania, in contrast with some other states, resources devoted to pasture plant improvement have not been reduced during the past few years. The work has been focused largely on selecting [rather than breeding] cultivars of new plants from introduced populations that are better adapted to the prevailing environment than those available hitherto. Most such activities are publicly funded with the R & D undertaken largely through the Tasmanian Institute of Agricultural Research [TIAR] (which combines the expertise of the Department of Primary Industry and Forestry [DPIF] and the University of Tasmania), with DPIF responsible for extension and the advisory role. Agreements are in place with Wrightson Seeds Ltd for the commercialisation of some potential new cultivars.

Although the staffing level has been reduced because of funding restrictions, the phalaris improvement program, undertaken by CSIRO in Canberra, has so far managed to retain sufficient public funding to maintain some of its core activities. However, it has come to rely increasingly on support from both the former AWI [for specific breeding objectives] and MLA for investigations on toxicity. A small annual grant from Seedco has also assisted the core program develop cultivars for specific conditions. In addition, biotechnology research on pasture legumes has been a major focus for other CSIRO work in Canberra during the past decade. MLA has made a major contribution to this work since 1992.

Changes in the role of seed companies

Significant changes have occurred in the Australian pasture seed industry during the past few years. All the big companies are now owned by overseas interests. The seed industry is now much more part of a global operation than it was even five years ago and the SIAA has undergone quite dramatic changes in its thinking on the production and sales of seeds. Multinational companies usually rationalise their activities, often making the necessary crosses between potential parent plants at one world site. For example, the company of which Heritage Seeds Pty Ltd now forms a part, undertakes the crossing of ryegrasses in New Zealand, white clovers in Australia, and cocksfoot and tall fescue in France. Evaluation of the progeny then occurs in target countries.

Plant Breeders Rights have created an environment for the development and marketing of proprietary seeds. Increased costs, such as those associated with both the development of these cultivars and of R & D, and the expense of drawing up legal agreements e.g. to cover responsibilities of participants or purchase the right to use IP, has meant that much more seed of a new cultivar needs to be sold to make its development viable than was the case even a few years ago. For example, in 1997, a senior seed executive quoted annual sales figures of 50 and 100-120 t of white clover and ryegrasses, respectively, required to break even. Five years later, the same executive raised these thresholds to 150 and 300 t, respectively. Farmers are willing to pay a premium for seed provided they see value for money, and seed companies have to decide just how large a premium the market will bear.

Estimated annual sales of seed of the main pasture plants needed to satisfy the domestic market are: some 6,200 tonnes of ryegrasses [somewhat less than 60% perennial ryegrass and more than 40% annual ryegrass, to which there has been a noticeable swing in recent years]; 2,500 t of lucerne [a growing market]; 2,300 t of subterranean clover; 1,800 t of annual medics; and 800 t of white clover. The only other significant, recent change in the market has been the steep increase in the annual demand for tall fescue, now variously estimated at between 400 and 500 t, up from about 100 t a few years ago [Coad, pers

comm]. The ryegrasses and tall fescue are the only pasture seeds imported in significant tonnage.

In contrast, Australia has quite large export sales and there is potential to increase this market. During 1997-98, the most recent accurate figures, about 7,700 t of temperate legume seeds were sold to overseas markets, with a value of $18.7 m; lucerne accounted for almost 4,000 t. Comparable export figures for temperate grasses were some 950 t, with a value of $ 2.17 m, and for tropical and sub tropical plants [almost all grasses] approximately 685 t sold for $ 2.90 m. The fact that every major world climate can be found within Australia makes the country an attractive proposition for seed production and marketing. It is not surprising, therefore, that increasing exports of pasture seeds remains the biggest opportunity for expansion of the industry. Recent changes should help achieve this objective with the increasing importance of proprietary cultivars a significant factor. Public cultivars are associated with seed gluts and shortages and with price uncertainty. In contrast, because the areas sown for seed production of proprietary cultivars can be controlled, greater coincidence of seed supply and demand can be achieved resulting in more uniform and predictable price levels.

Activities of R & D Corporations

In addition to MLA, 3 RIDCs have made significant investments into pasture plant improvement and one has provided some input into this objective. AWI supports the improvement of legumes under the NAPLIP program, having also invested in the breeding of improved cultivars of perennial pasture plants such as phalaris and lucerne. DRDC has invested substantially both in conventional breeding of improved cultivars of white clover and perennial ryegrass, plants which provide most of the feedbase for the dairy industry, and in the development of transgenic cultivars. GRDC has made substantial investments in NAPLIP [supporting work focused on new annual and perennial legumes], breeding improved lucernes [by contributing to the funding of the SARDI program for WA, and the NSW Ag program], and in the CRC for Plant-based Management of Dryland Salinity. RIRDC, with its more limited resources, covers the R & D on seed production of the levied pasture plants [clovers, annual medics, lucerne and serradella] and also has a small fodder industry program, which has some relevance to the dairy industry.

Our judgement therefore was that AWI, DRDC and GRDC would provide information of most value for this review. However, we also approached RIRDC and senior members of LWA, which appeared of increasing relevance to the activities of MLA. We were able to arrange discussions with representatives of all the above RIRCs except AWI. We soughtinformation on the procedures that the Corporations used for [i] choosing projects in which to invest, [ii] monitoring the investigations, and [iii] using the outcomes of the work. We were also interested in their involvement in new technology and in any constraints rising from IP and GMO considerations. Further, we had access to the review by Fennessy and Barlow “Future directions for plant breeding research for the dairy industry of Australia” [2001], commissioned by DRDC and DNRE, and the draft report by Stahle, commissioned by AWI and MLA, covering the role of plant biotechnology in complementing conventional breeding of new pasture plants.

Investment procedures

A common feature of the Corporations is the consultations they have with the industry they serve in the development both of the R & D Policy or Strategy and the identification of specific programs or projects for investment. The funds available affect the range of work in which investment might be possible; they also influence the processes developed to determine the Strategy and identify the projects. The extremes in available funds for R & D

of those RIRCs we were able to contact are RIRDC and GRDC. RIRDC has some $300,000 a year available for investment in the pasture seeds R & D program. In contrast, GRDC has total funds of well over $100m per annum, a sizeable portion of which is used for investment into pasture programs and projects of relevance to grain production. The 5-year RIRDC R & D Pasture Seeds Program is developed by a one day workshop, including representatives of seed growers, seed companies and researchers who determine the 5 or 6 most important key industry issues. Choice of specific projects for investment relies heavily on the advice of the Corporation"s Seed Industry R & D Advisory Committee.

Procedures are especially well developed in GRDC where the R & D Policy and Philosophy is determined by a National Panel, consisting of the Executive Management and the Chairs of the 3 Regional Panels. These Panels have their own budget and determine priority areas. Panel representatives are on Program teams [there are programs for different areas], which ensures that the chosen projects fall within the national policy. The projects are assessed both for their priority and science, with their value to growers integral to decisions. The continuing and successful relationship which DRDC has developed with the dairy industry includes the frequent use of discussion groups and workshops to help determine R & D investments.

While the GRDC and DRDC processes could have value for MLA, we believe that the steps taken by the Company to obtain industry input in developing strategic R & D plans for the red meat industries in southern Australia [see p 101] should be used as a basis for obtaining industry input for future MLA investment in pasture improvement.

Reporting and use of project outcomes

Most R & D corporations, including DRDC and GRDC, require milestone, annual and final reports to show the progress of project investigations. Larger Corporations undertake reviews of major projects [normally done by independent outsiders] either at the time of their completion or before making a decision on whether to extend the investment. Further, workshops organised to discuss the project outcomes are not uncommon.

Our clear impression is that DRDC and GRDC procedures for reporting on projects, and keeping records of their outcomes, were better than those which have been used by MLA. Recommendations for improving MLA procedures [including project monitoring and keeping records on project outcomes] have been made [see pp 18-19].

DRDC and GRDC have developed successful procedures for keeping producers informed of any significant developments, with GRDC having particularly effective tools for promoting awareness. These include the use of the media, through a series of GRDC publications, participation in field days and conferences, contracts to provide grower and adviser updates and an email service.

Intellectual Property

Most of the Corporations that we contacted have some experience with IP, though the Board members of one RDC appear split on the relative importance that should be accorded to public good relative to monetary reward through IP. However, there was unanimous agreement that any such monetary gain was secondary to the interests of the producers they served.

Differences exist in the extent of the involvement of the Corporations in biotechnology as it relates to pasture plants. For example, any such involvement was said to be „some way down the track" in RIRDC, whilst GRDC has considerable interest in the use of

biotechnology in grains, but none in pasture plants. In contrast, DRDC has invested heavily in new technology and all the indications are that the Corporation will increase its investment in this field. [It is interesting to record that some milk processors have instigated a moratorium on transgenic cultivars].

Whilst there have been few problems so far, it is clear that freedom to use IP is paramount in the investment decisions that Corporations make. As one interviewee put it „if this freedom was lost, we would walk away"; this sentiment was supported by the other RIDC representatives to whom we spoke. A similar outcome seems likely if the management of IP becomes too difficult. One longstanding member of an RDC questioned whether individual Corporations should attempt to manage an area which is becoming increasingly complex. He argued strongly that they should develop agreed mechanisms for managing IP, cultivar development and commercialisation. He further suggested that they should consider the possibility of contracting the management of IP to an independent outside body.

Recommendation

MLA should consider whether to make decisions on IP policy, managing IP, cultivar development and commercialisation independent of other RDCs, or attempt to develop agreed principles and mechanisms with other Corporations

Summary

° RDCs supporting R & D in pasture improvement have developed mechanisms enabling continuing contact with the industries they serve to help determine their strategy for investment. GRDC and DRDC have processes which are particularly effective in maintaining continuing interaction with their industries

° DRDC and GRDC procedures for monitoring projects and keeping records on their outcomes are better than those which have been used by MLA [see Recommendations (pp 18-19) to rectify this situation]

° Clear differences exist between RDCs in their level of involvement with IP in pasture plant improvement, with DRDC having a major interest and GRDC with no present involvement. Management of IP is an issue of increasing importance and complexity

Role of contributors to pasture plant improvement

There was unanimity amongst review participants that the public and private sectors and the RDCs should all continue to play important and complementary roles in the improvement of pasture plants. Their responsibilities flow logically from the benefits to their constituents derived from the enhanced performance of new species and cultivars. The public sector should thus cater for public good requirements and market failure, the RDCs the interests of the two groups financing their operations namely the Federal Government [representing the wider community] and the pastoral industries, whilst seed companies need a satisfactory level of return on investment.

The public good contribution of pasture plant improvement - with benefits based on economic [increased productivity and improved living standards], sociological [stronger rural communities] and environmental [the need to reverse or reduce degradation] grounds - is not difficult to demonstrate. Neither is the case for RDCs investing in projects which have clear benefits flowing to producers [through increased pasture productivity] and to the community

at large [through their positive effect on the environment]. Market considerations will determine the extent of the investment of the private sector in plant improvement.

Appropriate organisational structures for pasture plant improvement vary according to the particular circumstances. The public sector has responsibility for delivering new cultivars with demand for low volumes of seed e.g. phalaris and many improved subterranean clover varieties. It will have an increasing role in developing improved plants for maintaining pasture stability and confronting environmental problems. Breeding cultivars where only low seed volumes are needed is not viable because seed prices would be set too high; however, if the price of seed is taken out of the equation, benefits to niche farmers could outweigh the costs. There has to be some public benefit in public sector breeding e.g. maintaining producers in a particular area, and/or the public sector has to be willing either to accept a lower rate of return than the private sector or subsidise the breeding. Similarly, producers can"t capture enough benefits to justify paying the high price needed for the breeding for environmental objectives to be economically viable. The public sector counts all the benefits, thus producing seed may pay even when required volumes are low. There are some implications in this analysis for MLA, which may have a larger role in supporting projects in which the private sector is reticent to invest. Whilst there is no reason why MLA should not support both public and private sector projects, in most cases supporting pasture plant improvement in the public sector would be more effective, especially where public good contributes a large proportion of the total benefits and where leverage of public funds is likely.

It seems certain that the future of pasture plant breeding for high input systems [what seed companies describe as the middle to upper end of the market] will lie increasingly with the private sector. Whether this responsibility will be undertaken entirely by the sector, or through joint ventures or alliances involving the public sector, will depend largely on the extent of relevant expertise in the companies involved. Companies vary widely in their level of expertise though there is evidence that some, at least, are increasing this rapidly. In any event, seed companies have little interest in the „lower end" of the market, where only small volumes of seed are sold.

Joint ventures, usually involving the public and private sectors and one or more R & D Corporations, are being used increasingly in the delivery of improved cultivars, and it is not unusual for longer term alliances to be developed for this purpose. A number of review participants spoke of the need for, and the value of, joint ventures. Several e.g. the SARDI lucerne, NSW Ag/AgResearch white clover and the CSIRO phalaris breeding programs, as well as the CSIRO bloat-safe biotechnology work, were all cited as „good models". [MLA has been and/or is involved in all four examples]. Although there were minor differences in their organisational arrangements, they all included regular meetings of the participants to agree on objectives, protect the interests of the partners [e.g. their share of royalties] and monitor progress. Upfront agreement between all parties on major issues was said to be vital whilst the presence, wherever possible, of the commercial partner at the beginning of the venture was cited as an important objective. Reservations expressed on joint ventures were that [i] on occasion, the parties had different agenda e.g. on the rate at which cultivars should be released, and [ii] agreements became more difficult as the numbers of partners increased. More than one respondent argued for no more partners than were necessary to achieve the objectives of the project.

R & D Corporations have a logical basis for investing in public programs and joint ventures. Further, MLA, through its Donor Company, also has the opportunity to participate in a number of private sector ventures [see response to Objective 4]. Respondents proffered little knowledge of this Company. However, when the opportunity was pointed out to seed company executives, they all expressed their support for the concept and had little difficulty

in nominating topics for support. The executives recommended that the availability of the MLA Donor Company should be advertised more widely, a proposition we endorse.

Conclusions

Reduced public funding and changes to the seed industry have both had profound effects on pasture plant improvement in Australia, a small player in the world seeds market. Decreased public funding has resulted in a reduction in the number of core breeders and relevant specialists e.g. entomologists and plant pathologists. As a result, a number of breeding programs and associated activities have either reached the stage when they are no longer viable or are struggling to survive. The private sector can be expected to assume responsibility for breeding new cultivars that are likely to provide a competitive edge in the market and be profitable. However, as costs increase, the number of commercially viable cultivar improvement programs will probably be reduced further. Facilities in Australia could be used to breed cultivars, e.g. of lucerne and white clover, for the overseas market, but it is not realistic to expect seed companies to subsidise non-viable activities.

Three options remain open for the commercialisation of improved cultivars developed for smaller markets. A number of Australian seed companies, which are not part of large multinationals, have expressed interest in commercialising several of these cultivars, and have signed agreements to do so. However, the long term future of small seed companies is an open question. Where no private sector interest exists, a decision could be reached to release the improved plants either as proprietary, or unprotected, cultivars; this latter situation obtains with many cultivars of annual legumes.

A number of the developments that have affected plant improvement in southern Australia have real implications for the red meat industries. The products of some breeding programs are important to provide long term pasture stability and a sustainable livelihood for farmers and graziers, vital for the well-being of the wider community in rural Australia. Other programs will be needed to develop plants to slow or prevent further environmental degradation or assist its recovery. Salinity may be the most threatening example of such degradation, but it is no means the only one.

These improvement programs have a major public good component and unless they continue to be supported by public investment, they will simply cease to exist. We are in no doubt that there remains an important role for public breeding. We thus endorse the principle, articulated by many of the respondents to our questionnaires, that it is a public responsibility [to be implemented by State and Commonwealth Governments] to provide the capability to maintain public breeding at a viable level, together with sufficient specialists to provide informed advice on how best to respond to any major problem, such as a potentially devastating pest or disease, which might affect Australian pastures. This would require the funding of a minimum number of core staff and the necessary associated infrastructure. We envisage that such staff and infrastructure would have a national responsibility which could result in some rationalisation of their roles and perhaps even their siting.

We do not think that it is the role of R&D Corporations, especially those with a relatively small budget, to fund the establishment and continuing activities of a pasture plant improvement program. Rather, they should support specific projects, funding any necessary staff and perhaps contributing to the purchase of any specialised equipment that may be needed.

Summary

° Major changes have occurred in pasture plant improvement since 1990, particularly in the level of public funding

° Delivery of improved pasture plants was then accepted as a public responsibility; development of commercially viable improvement programs now lies increasingly in the private sector

° Reduced public investment in pasture plant improvement, though considerable overall, has been uneven. In NZ, all pasture plant breeding is now undertaken by the private sector, whilst in Victoria, a recent decision has been made to withdraw public funding from most conventional breeding. Varying levels of public investment in pasture plant improvement programs still occur in the other states

° Profound changes in the seed industry, with major Australian companies now owned by overseas interests and thus part of the global market for the production and sale of pasture seeds, have had major implications for plant improvement

° Activities of selected R & D Corporations have been described briefly, and their procedures for investing in, and monitoring of, projects and their use of project outcomes outlined. A brief analysis is made of the Corporations‟ experience in, and management of, IP

° Organisational structures for the delivery of improved cultivars, including the roles of the public and private sectors and the R & D Corporations, have been briefly discussed

° The importance of continuing and viable public plant breeding is argued, not only to increase production, but also to maintain long term stability of pastures and combat environmental problems

Conventional breeding and biotechnology

Relative levels of genetic gains from the two approaches to plant improvement can only be assessed by comparing measured gains from conventional breeding, and making informed judgements on the extent of the potential gain achievable through biotechnology. A welter of data exists on the former. However, as no GM pasture plant cultivars are yet available commercially anywhere in the world, it is not surprising that there is considerable divergence of view on the level of potential gains possible by using biotechnology

Genetic gains through conventional breeding

Much of the information on genetic gains from conventional breeding, kindly supplied by Dr Derek Woodfield (pers comm), has been collected in New Zealand. Data on such gains have been obtained from a number of pasture legumes and grasses and have covered a range of traits [Table 4]. It will be seen that the genetic gains in measured forage yields ranged quite widely, both within and between species. The annual gains within lucerne varied between trials from 0.18 and 1.07% per year; comparable figures for red clover and white clover were 0.21 and 2.83 % per year and 0.60 and 1.49%, respectively [Table 4].

Results of a long term comparison of genetic gains in forage yields of NZ bred white clover cultivars in 8 trials under sheep grazing, relative to the performance of Grasslands Huia, are particularly interesting. The gain for the period of 30 years from the late 1950s averaged

0.4% per year. In contrast, since 1985, the annual gains have been more than 2.5% - making an average of 1.49% over a 40-year period.

Genetic gains in annual DM production recorded for grasses have been similar to those on legumes. Whilst gains in forage yields for annual ryegrass were slightly more than 1 % per year, and in tall fescue marginally below 1%, the highest recorded gains in perennial ryegrass were 0.73% per year [Table 4].

Table 4. Estimates of the rates of genetic gains in temperate forage species (Information supplied by Woodfield, pers comm).

Species/Trait	Benchmark Variety	Trials/Varieties	Genetic gain (% yr-1)	Reference
Lucerne				
Forage Yield	Vernal	14 trials (150 var)	0.26	Hill et al 1988
Forage Yield	Cossack, Ladak	2 trials (12 var)	0.18	Holland & Bingham,1994
Forage Yield	Saranac	Multiple trials (80 var)	0.18-1.07	McKersie 1997
Forage Yield	Wairau	3 trials (5 NZ var)	0.35	Woodfield 1999
Red Clover				
Forage Yield	Grasslands Turoa	G. Hamua, Pawera	0.43	Anderson 1973
Forage Yield	G. Hamua (2x)	G. Colenso (2x)	0.21	Clayton et al 1993
Forage Yield	G. Pawera (4x)	G27 (4x)	1.39	Rumball et al 1997
White Clover				
Forage Yield - Sheep grazing	G. Huia	8 trials (10 var)	1.49	Woodfield 1999
Forage Yield - Cattle grazing	G. Huia	5 trials (9 var)	1.21	Woodfield 1999
Stolon density	G. Huia	5 trials (9 var)	1.09	Woodfield 1999
Clover content	G. Huia	110 var	0.60	Woodfield & Caradus 1994
Nitrogen fixation	G. Huia	3 trials (7 var)	1.19	Woodfield 1999
Annual ryegrass	G. Moata	18 trials (11 var)	1.18	Easton et al 1997
Perennial ryegrass				
G. Nui	7 trials (8 var)	0.25	Pennell et al 1990	
Ruanui	8 trials	0.60	Kerr 1987	
Elliot, G. Nui, Yatsyn-1	G. Nui	1 trial (7 var)	0.73	Tom et al 1998
Yatsyn-1,	G. Nui	17 trials (21 var)	0.60	Easton et al 2001
Tall fescue				
	G. Roa	1 trial (G. Advance)	0.98	Frazer & Lyons 1994

Significant annual gains have also been recorded for lamb growth - of 0.33 and 0.48% in two trials, with the higher figure of 1.37% in lamb live weight gain [Table 5] reflecting improved pasture quality. Recent work in the USA has shown that white clover cultivars tolerant to heat and drought have resulted in an increase in excess of 100 kg beef production per hectare compared with the industry standard cultivar.

Table 5. Genetic improvements in forage quality and animal performance of temperate forage grass and legume species (from Woodfield, 1999)

Species	Trait	Benchmark cultivar	Cultivars	Genetic gain (%/yr.)	Reference
Perennial & Norris ryegrass	Lamb live weight gain	G. Nui	HD Aries Quartet	1.37	Westwood 1999
Tall fescue	Lamb growth rate	G. Roa	G. Advance	0.87	Frazer & Lyons 1994
Red clover	Formononetin	G. Pawera (4x)	G27 (4x)	2.83	Rumball et al 1997
White clover	Lamb growth rate	G. Huia	G. Demand	0.33	Ryan & Widdup 1997
White clover	Lamb growth rate	G. Huia	G. Tahora	0.48	Chapman et al. 1993

Uses of biotechnology

The most obvious value of biotechnology has been thought to be through using transgenics, providing additional genetic variation for the plant breeder and thus enabling the potential incorporation of valuable traits, previously inaccessible, into improved cultivars. In reality, biotechnology provides a range of opportunities for better understanding genetic control of plant traits and using some of this knowledge for improving the performance of pasture plants.

Genomics, or gene sequencing, is being undertaken in various parts of the world on a number of organisms including perennial ryegrass, white clover and tall fescue. It has the potential to link the expression of important phenotypic characters to their underlying physiology and metabolism, and hence to the genes responsible for these traits. This provides forage breeders with real opportunities to systematically accumulate genes responsible for controlling quantitative traits. As complete sequences will be possible for these genes, markers can be developed enabling their accurate transfer into desirable genetic backgrounds. The genetic control of quantitative characters should also be able to be determined [Woodfield, pers comm].

There are many uses of genetic markers. They include understanding and capturing heterosis, identifying quantitative trait loci, developing detailed genetic maps, introgressing unique genetic variation from conventional and transgenic sources, conducting marker-assisted selection and determining the factors involved in genotype x environmental interactions [Woodfield, pers comm]. The use of molecular marker-assisted selection [MAS] provides the greatest short-term impact of biotechnology. The biggest benefits of MAS are likely to be realised in shortening the selection cycle in outbreeding perennial forage crops. For example, because of variation in the severity of winter, selection for winter hardiness takes 3 to 5 years - a time period that could be shortened considerably if markers linked to winter survival could be identified [Brummer *et al*., 2000].

Potential yield gains through transgenics

In responding to the question of the level of potential genetic gain through transgenics, one highly respected researcher, Dr T J Higgins, estimated that a 10% increase was achievable by transgenic lucerne and white clover resistant to alfalfa mosaic virus; this figure is based on glasshouse and field plots. He expressed confidence that even bigger gains were likely from salinity tolerant transgenic lucernes. One senior seed company executive felt that the gains of transgenic white clover and lucerne could be considerably greater than 10% and opined a figure of 30% after 3 years when mortality had taken its toll on non-resistant cultivars.

A number of problems require solution before the potential of transgenics can be realised. In addition to some technical difficulties, which the biotechnologists are confident can be overcome, costs - the outlays needed for R & D, the expenses associated with IP, and the costs of compliance - together with community attitudes, loom as significant hurdles. In fact, the cost of delivery of transgenic cultivars has become so expensive that some now doubt its viability. Further, there is increasing resistance by the wider community to the use of GMOs, which are presently banned in NZ and in Tasmania.

Whatever the attitude to transgenics, it is taking much longer for them to be available commercially than originally thought. It is doubtful whether any such cultivars will be released for 5 years or so; the most optimistic estimates are for the first virus-resistant legumes to be released in 2006/07, and for bloat safe legumes and a nematode resistant white clover to follow in 2008/09. It will take a further 3 or 4 years after their release before such cultivars become available commercially. Nevertheless, we believe that transgenic cultivars, with their clear benefits, will become available ultimately. A national process, typified by that in operation for canola, is seen as a sensible way to go, with the Plant Industry Steering Committee having the responsibility of monitoring the activities.

Conventional breeding and biotechnology - complementary roles in pasture plant improvement

The potential role of biotechnology in plant improvement has been clarified during the past decade. Earlier claims by enthusiastic practitioners that it would revolutionise plant improvement - rendering breeders redundant within a few years - have been shown to be way off the mark. It is now appreciated that biotechnology will not, in itself, deliver improved cultivars. What it has done is to provide a number of extra tools to assist their development. However, unless the plant breeder is part of the delivery system, transgenic cultivars will never reach the stage of commercialisation. Biotechnology and conventional breeding thus have complementary roles in pasture plant improvement - both are required in the development of new cultivars with maximum enhanced performance.

The greatest gains from MAS will be in the selection of plant traits with low or moderate heritability, those displaying large genotype x environment interactions, and those which require a lengthy screening period for selection of superior phenotypes. Considerable work is being undertaken both in Australasia and other parts of the world to develop transgenic cultivars with desirable traits [see response to ToR-Objective 3]. Clearly, this technology has considerable potential but, as discussed earlier, is taking longer than first thought to achieve its objectives. It is important to incorporate transgenic material into elite germplasm containing the other genes being selected in the program, thus reducing the necessary period of selection. Field trials are an important component of any breeding program, whether or not transgenics are being evaluated. Efficient delivery of improved pasture plants requires not only cultivars that are adapted to the prevailing conditions and have a superior performance, but also effective seed production and a good system of distribution.

There is no doubt that conventional breeding will be important for the foreseeable future in developing improved cultivars of both perennial, and annual forage plants. Unlike biotechnology, such breeding is not subjected to any legal requirements and though progress in improving quantitatively controlled traits is slow, there has been little sign of any reduction in the rate of genetic gain - indeed some recent results suggest the contrary. If an objective can be achieved through conventional breeding, using MAS if appropriate to speed up the process, this is clearly the best option. However, transgenics have the potential for much greater rates of gain, achievable in one step, than the average incremental gains which characterise conventional breeding, and are the only way to introduce extra-specific variation into a population. Further, it is conceivable, though a long way off, that biotechnology could change the whole breeding system e.g. by creating a range of apomicts, and thus a diverse population with a range of clonally-multiplying genotypes.

Biotechnology and the seeds industry

One effect of globalisation has been the purchase by large biotechnology companies of breeding programs, seed companies and access to superior germplasm, for use as required. Within Australia, there was some difference of opinion between seed company executives on the future role of biotechnology in the industry. The chief executives of two large companies were clear that it was an essential component for their future viability. Their attitudes were graphically described by one - "if we don't embrace biotechnology we'll be dead in 20 years". One of these was sufficiently confident to declare that transgenic cultivars would be released in two years. In contrast, the Chief Executive of a smaller, but quite successful company, said that a combination of the high costs of compliance, coupled with the strongly negative community attitude, would prevent the commercialisation of any of the present transgenic cultivars now nearing release.

Summary

° Genetic gains from conventional breeding on a range of herbage species have been recorded for a number of plant traits and indices of animal production. DM gains have ranged between 0.18% and 2.83% per annum, with yearly gains of NZ bred cultivars of white clover on grazed plots averaging more than 2.5% since 1985. Annual liveweight gains of lambs have varied between 0.33% and 1.37%

° One-off gains of transgenic plants can only be estimated as no GM cultivars of pasture plants are yet available commercially. Such estimates range from a 10% to 30% increase in DM production. Problems of realising gains from genetically modified plants are canvassed

° Seed industry attitudes to transgenics are described briefly

° Other uses of biotechnology in plant improvement, especially gene sequencing and marker assisted selection, are discussed

° The complementary roles of biotechnology and conventional breeding in pasture plant improvement to achieve maximum improved performance are described and their inter-relationship stressed. Biotechnology provides a number of extra tools to help the breeder who is essential for the development of new cultivars.

Objective 2 Identify opportunities for pasture improvement considering the individual lamb, sheepmeat and beef business needs, community needs and the technologies that are now available

Opinions expressed by the review participants confirmed our belief that many opportunities exist for improving and sustaining pasture productivity in southern Australia. These opportunities include the provision of better plants, improving pasture and stock management and improving the flow of information of recent R & D findings to producers. Not all the opportunities discussed need MLA investment. We believe that some are already being addressed and are well resourced. Others seem to us to be of lower priority for support from the Company. Nevertheless, the identification and brief analysis of a range of opportunities is needed, not only to respond to Objective 2, but also to provide a platform for responding to Objective 4.

Improved pasture plants

New annual legumes for the WSZ

There can be no doubt of the need to increase the range of pasture plants suited to the WSZ. Annual legumes, better adapted than subterranean clover and the annual medics to the growing conditions in some areas, are required, particularly to meet the range of maturity and levels of hardseededness needed. Significant steps towards achieving this important opportunity to improve pasture output will occur during the next few years with the release of a number of new annual cultivars from the WA-based legume improvement program. These cultivars include several pink and yellow serradellas, some that are easier to harvest and thresh, and others later maturing, than current varieties. Apart from their improved adaptation to a number of areas, the serradellas are able to nodulate with a range of native *Bradyrhizobia*, have deep roots and are less demanding of P and K which are nearing exhaustion in many WA soils.

Other annual legumes nearing commercialisation include biserrula [*Biserrula pelicinus*] cv Casbah, which is well adapted to neutral to moderately acid soils and better able to regenerate in a wheat/pasture/wheat/pasture rotation than either subterranean clover or the annual medics. The plant is unpalatable during flowering and seed production, thus enabling stock to be retained on the pasture to eat out weeds. Another interesting plant nearing release is gland clover [*Trifolium glandiferum*], a plant which is highly resistant to a range of insects and thus important in the fight against red legged earth mite and the blue oat mite. Additional annual legumes are being developed to occupy unfilled or underfilled niches in an improvement program which provides a clear and continuing opportunity for increasing output in the WSZ.

New perennials for the WSZ

The search for deep rooted perennial plants and salt tolerant species, to address the environmental problems associated with dryland salinity in southern Australia, is just as important as continuing the development of new annual legumes. Increasing salinity [with the area affected predicted to more than double within 50 years] threatens the sustainability of farming systems, and thus the livelihood of individual farmers, particularly in WA and in the Murray Darling Basin. There is also increasing community concern at the loss of biodiversity, damage to infrastructure and degradation of river systems caused by salt flushed from agricultural land.

SARDI [through a GRDC-supported program] has assumed responsibility for breeding lucerne cultivars tolerant of saline conditions. While lucerne is an excellent plant for

reducing recharge, it is poorly adapted to acid and waterlogged soils as well as to some climates. A nationally integrated program, to select new perennial legumes, perennial grasses, shrubs and salt tolerant species adapted to such conditions, has been developed by the CRC for Plant-Based Management of Dryland Salinity. Sustainability is a major focus of this program in which a range of such perennial pasture plants will be sourced from a number of centres within Australia and overseas to identify new plants which can be introduced into farming systems to improve hydrologic stability. Discharge areas, where saline water causes salt scalds or large flushes of salt into river systems, are also an important objective of the program. Plants able to increase ground cover and lower water tables will help stabilise the affected areas and reduce salt outflow into rivers.

Perennial legumes already showing some potential to achieve these objectives include sulla [*Hedysarum*], *Lotus* spp., *Dorycnium* spp., and *Galega* spp. These, and other promising plants, will be evaluated nationally. Further investigations planned by the CRC include the development of [i] new farm systems, based on these new plants, for incorporation into crop rotations, and [ii] new land use systems such as the stabilisation of discharge areas.

In contrast to the continuing work to develop improved annual legumes, which appears quite well resourced, we believe that the program to select new perennial plants by the CRC for Plant-Based Management of Dryland Salinity needs further investment. A proposal for such support has been included, and has scored well, in the modelling of possible areas for MLA investment [see section on Analysis of Some Opportunities for R & D Investment - Opportunity 1]. We strongly recommend that MLA invest in this program, which has objectives which are highly relevant to both production and environmental issues.

The new annual and perennial plants will contribute high quality feed for the livestock industries and they are especially important for lamb and beef production. It seems certain that these new plants will drive profound changes in farming and grazing in southern Australia. For example, in WA alone, it seems not unreasonable to expect the current sheep population of 25 m to increase to 30 -32 m during the next 10 years.

New species for niche environments

Current pasture plants are not well adapted to the growing conditions in a number of environments. For example, on the NW Slopes and Plains of NSW,where the performance of winter annuals is diminished by the summer-dominant pattern of rainfall, gains are likely from persistent legumes and perhaps subtropical grasses. This is an important target for the new species that may be identified amongst the activities of the CRC for Plant-Based Management of Dryland Salinity.

In Tasmania, in the HRZ, the deficiencies of the plants now available are especially apparent. A recent survey showed no trace of subterranean clover [the most widely recommended pasture legume] in more than 100,000 of the 160,000 ha on which it had been sown three years earlier. Further, the performance of the commonly used grasses in the state, particularly their winter production, leaves much to be desired. A genuine opportunity thus exists for selecting plants better adapted to the prevailing growing conditions. Following the assembling and field evaluation of a range of legumes and grasses, several populations which outperform the present cultivars have been identified. They include a number of legumes, one of which, a selection of *Ornithopus,* has outyielded subterranean clover several fold and, unlike this latter plant, is compatible with cocksfoot and phalaris. Another selection, of Caucasian clover (*Trifolium ambiguum*), a perennial legume adapted to dry, cool areas, has persisted for 10 years in pastures in the difficult climate in central Tasmania and even increased in vigour and content. A number of cocksfoot selections have also performed well, producing up to 7 times as much herbage

during winter as the cultivar, Porto, widely recognised as a well adapted cocksfoot with good winter growth.

This Tasmanian program is well on the way to realising the opportunity to replace poorly adapted species with better performing plants. The fairly extensive range of genetic diversity now available, continuing state government support, and arrangements with a seed company for the commercialisation of some new cultivars, lead us to conclude that a range of improved varieties will become available over the next few years. There seem few constraints to achieving this objective for which no major outside investment of funds appears necessary.

Selecting plants for low input systems

Several respondents argued the need for some investment into low input plants and systems, a proposition we support as a significant opportunity to advance productivity and reduce environmental degradation. A logical starting point for such work would be to build on the results of a previous MLA project [TR. 045], a national investigation involving 9 sites and 5 government agencies. In the study, a number of populations of perennial grasses, several native and the others exotic, were shown to perform well over a number of low input sites [low fertility, acid, alkaline and saline soils, and low rainfall areas].

The selection and release of native and exotic perennial grasses for use in pastures and for conservation in adverse environments requires : -

° long term persistence and productivity in swards, including information on any seedling regeneration, in low input environments. [In TR. 045, data were collected [i] for a maximum of 2.5 years, not enough to determine long term performance, and [ii] from spaced plants which may not indicate their sward performance. Grazing the swards would both point to the performance of these plants under more realistic conditions and enable the collection of information on their palatability]

° reliable establishment and good seed production. Poor establishment and difficulties in seed production are always major constraints to the adoption of native cultivars

While it is difficult to estimate the likely effects of such work on animal enterprises, the results could be beneficial to the production of sheepmeat in particular. Low input plants could also provide a real opportunity to make a positive contribution to pasture sustainability and thus reduce environmental degradation. We understand that a submission is likely to be made to MLA for support of a national study to evaluate low input plants and we have used a project in this field in our modelling exercise on possible investment opportunities. It scored well when subjected to the MLA scoring and benefit:cost analysis [see section on Analysis of Some Opportunities for R & D Investment - Opportunity 2]. We thus recommend that MLA invest in research on the evaluation and selection of plants for limiting environments, where the climate, terrain, soil attributes or hydrology are unsuitable for high input systems.

Improved cultivars for the HRZ

Bred cultivars, either already available commercially or to be released during the next few years from the DNRE perennial grasses and white clover improvement program, the SARDI lucerne breeding program, and the NSW Ag lucerne and white clover programs will have a positive impact on red meat production. Collectively, these new cultivars will: be better adapted to, and thus more persistent in, a range of growing conditions; have improved seasonal production, especially in autumn and winter; and, greater resistance to pests and

diseases. Several cultivars which have become available commercially during the past few years have replaced older varieties and some have expanded into new areas.

Yet further significant advances in the performance of pasture plants are possible, and we believe that opportunities exist for investing in plant improvement programs involving both conventional breeding and biotechnology. Many respondents pointed to the need for more persistent cultivars, and a number felt that improved quality, better seasonal growth and resistance to important pests and diseases, all provided significant opportunities for real productivity increases. Several mentioned low seed production as a significant obstacle, whilst others signalled lack of tolerance to adverse soil conditions [acidity, often associated with high aluminium levels, alkalinity, salinity and water logging] and the presence of toxic substances in the herbage, as the most important constraints on the wider use of a number of the present cultivars. Phalaris was quoted by several as a plant where significant advances had been made in reducing the risk of staggers; however, the problem of sudden death remains a major obstacle in a number of areas. Fear of bloat constrains the use of productive legumes.

Victorian farmers appear to have a particular problem with „ryegrass staggers" caused by endophyte toxins in ryegrass, which is said to impact on both plant and animal productivity and farm profitability. It is not clear how much this condition [including sub clinical effects] is caused by the environment but the producer members of the central committee of the Grassland Society of Victoria seem convinced that if the problem „could be addressed, there may be enormous gains to be had".

We recommend that MLA continue to invest in the conventional breeding of improved cultivars but not to develop „me-too" cultivars. We suggest funding only for the development of those cultivars with traits which would result in **major** improvements in performance e.g. increased persistence, measurably improved quality, significant out of season growth, resistance to crippling pests and diseases and elimination of toxic substances. We do not recommend investment in breeding work on endophytes - not because it is not important but because of the considerable effort being undertaken on this work in NZ - but accept that a case can be made for studies to determine the conditions under which animals are most vulnerable to endophyte poisoning.

Support could conceivably be provided to assist in the core activities of an existing successful breeding program e.g. the SARDI lucerne improvement program. Jointly funded by the SA government, Heritage Seeds, MLA, AWI and DRDC, the SARDI program has been very successful and it is our understanding that all parties wish this partnership to continue. However, we prefer any new support to plant breeding to be given to assist the attainment of specific objectives, which are detailed in our response to Objective 4 of the review.

The contribution of conventional breeding and biotechnology has already been discussed in principle. Suffice to say that there are a number of traits [e.g. bloat free white clover and lucerne; immunity, as distinct from most forms of resistance, to some pests and diseases; and lucernes tolerant to high levels of salinity] that can only be incorporated through the use of transgenics. They represent „quantum" advances and must provide a potentially considerable opportunity to improve pasture production. In spite of the problems of almost inevitable delay in commercialising transgenic cultivars, uncertain outcome, high costs and the negative community attitude to genetically modified material, we believe that MLA cannot afford not to invest in biotechnology.

We have included three scenarios in the structured analyses of opportunities that MLA could consider for further investment, two of plant improvement through conventional breeding

and one using biotechnology [see section on Analysis of Some Opportunities for R & D Investment - Opportunities 3-5].

Evaluation of new plants

Where high performing pasture species are introduced into an area for the first time, their evaluation is normally relatively easy and non-controversial. Simple replicated experiments, or even demonstration plots, are usually enough to show their superiority. It is a different story with cultivars, especially where only small differences in performance are being measured. Deficiencies in the methodology normally used for the evaluation of these cultivars were cited by a surprising number of those answering our questionnaires. There is no doubt that performance testing of cultivars, based essentially on DM production from small plots, leaves much to be desired.

While there were criticisms about [i] the sale of cultivars for areas where they had not been tested, and [ii] the lack of information on their compatibility with other species with which they were normally grown, the most obvious shortcoming in the present method of cultivar evaluation is the lack of, or limited importance placed on, the animal. Scant attention is normally paid to herbage quality, response to grazing, palatability, animal intake and other aspects of animal performance, with little on-farm assessment that some producers thought essential. Thus, the relative value, and any limitations, which new cultivars may have for animal production are often largely unknown at the time of their sale.

One seed company has a policy of selling seeds on the basis of their animal performance and there are data showing superior animal production from tall fescue cultivars with lower DM yields than other varieties of the same species. Yet this policy is the exception rather than the rule.

While there appears unanimity in accepting that present methods of assessing cultivar performance leave much to be desired, there is some difference in the thinking on whose responsibility it should be to take steps to improve this evaluation. The view in NZ appears to be to „leave it to the market", an opinion reiterating the stance on pasture plant breeding in that country. However, many respondents suggested the need for the collection of information to be independent of vested interests, with producers especially saying that cultivar evaluation should be undertaken by the public sector. Opinion within SIAA also seems divided on whether variety performance should be entirely a within-house matter. However, in spite of the demise of APPEC, one influential member of SIAA felt that „it was time to start again". Another expressed the view that the majority of those members of SIAA who were involved would „jump at the chance" to develop a more realistic method of evaluation, including some animal data, jointly developed and funded by the public and private sectors.

It would not be difficult to develop an improved, and relatively inexpensive, protocol for measuring cultivar performance, including some animal related data. We see this as an opportunity to improve the reliability of pasture plant evaluation and thus contribute to animal performance. We believe cultivar evaluation should be a joint responsibility of the public sector and SIAA and are loathe to recommend that MLA should commit major resources into any such development. However, we recommend that the Company [i] take the initiative to facilitate discussions between representatives of state governments and SIAA designed to develop an improved protocol for cultivar evaluation, including animal-related information, and [ii] make a modest investment in any agreed procedure.

Recommendation

MLA take the initiative to facilitate discussions between the public sector and SIAA to develop an improved protocol for cultivar evaluation and make a modest investment towards the establishment of any such agreed protocol

Other key factors affecting pasture improvement

Discussions with review participants and our own deliberations on, and knowledge of, the wider aspects of pasture improvement have been somewhat less detailed than those on pasture plant improvement, the original focus of the review. Nevertheless, we have enough information to have confidence in determining constraints and making recommendations [some specific] on R & D opportunities covering the range of factors potentially affecting pasture improvement.

Extension and Decision Support

Analysis of the responses to our questions on constraints and opportunities was revealing. For example, those which related to difficulties experienced in establishing pastures fell into two categories. In the case of novel plants, such as the new legumes now being released and native species being commercialised for the first time, information on the steps necessary to obtain good establishment should be an integral part of an „agronomic package", already developed and available when the seeds are sold. There can be no question of the opportunity, in fact the need, to provide such a package which can have obvious implications for pasture improvement. MLA could consider supporting such essential work.

In contrast, information required for successful establishment of the species commonly used in pasture improvement appears to be known, though not fully appreciated by all farmers. For example, in Victoria, considerable emphasis was placed on what was said to be deficiencies in our knowledge of pasture technology, which was rated as a high priority for R & D. Many producers, fearing failure to obtain a good establishment, had apparently concluded that sowing new pastures was not warranted. This frame of mind was thought to have been responsible for the characteristically low rates of pasture renovation, and thus low rates of adoption of new cultivars, in many areas of Victoria. Respondents concluded that removing this constraint to the thinking of producers would increase the frequency of pasture renovation and could easily double the rate of adoption of improved plant varieties.

The perception in Victoria contrasts sharply with that in NSW, where the establishment of pastures sown with commonly used plants was not seen as a problem by senior NSW administrators/scientists. Their thinking appears to be based on the greater availability and wider use of the NSW Ag Prime Pasture Programme for pasture establishment in New South Wales than in Victoria. This decision support program incorporates eight steps for planning, preparing, sowing and early management of newly established swards, which, if followed dramatically reduces the chances of failure. However, perceived differences in the importance of the problem of establishment in Vic and NSW were not picked up in ABS statistics.

The situation illustrates the vital role of extension in achieving increased pasture output. MLA should consider investment in such activities, especially supporting the national relaunch of DSSs which include practices which have been successful regionally or locally.

Establishment is just one of a number of perceived problem areas affecting pasture output that could be resolved if producers used the information already available - thereby converting a constraint to, into an opportunity for, pasture improvement. Another example springs from systems studies which have shown their value in both improving understanding

of the effect of various factors on pasture production and increasing the levels of animal output achieved under different growing conditions. Reference has already been made to PROGRAZE, a highly successful decision support system program. With its holistic approach, the program promotes productive pasture plants and enterprises, and incorporates optimal management strategies both for sustainability and profit and to minimise or reduce environmental degradation. There can be no doubt that PROGRAZE has catalysed changes in pasture management amongst those who have participated in its courses. It is a further example of the desirability of investing in extension activities, thereby improving the transfer of R & D findings to the producer. The extension of PROGRAZE nationally, together with other programs assisting decision making, provide considerable opportunities for further improvement in pasture production.

GrassGro is the most advanced support tool available for the pastoral industries. Not only does it incorporate a grazing system and has a potential use in sensitivity analysis, but it is a tool which can be used to estimate benchmarks for pasture measurements, calculate probabilities and train producers in risk assessment. Even so, Clark *et al.* [2000] believe that some refinement of GrassGro should be a priority research area. While we believe such a refinement could provide some opportunity to increase pasture output, we do not believe it to be high priority research for MLA investment.

It is enlightening to record that every person answering the question on future opportunities classified extension in the highest impact category for pasture improvement. We have no doubt that existing R & D findings, if fully used by red meat producers, would lead to considerably increased animal output from pastures that would also be reflected in net farm incomes. Investment in extension activities would probably represent the best opportunity for both a considerable, and the most immediate, impact on pasture improvement in southern Australia. We strongly recommend that MLA make a significant investment in extension, thereby assisting the transfer of research findings to producers.

Pasture Management

The present generally low level of pasture management was nominated as a constraint to pasture output almost as important as the failure of producers to use R & D findings. Many review participants pointed to the lack of coincidence in herbage supply and demand, with some opining that pastures which were set stocked without any consideration of the plants" phenology and seasonal DM production were inevitably tied to a level of animal output significantly lower than was possible. A case can be made for research to better understand the relationship between the growth and development of pasture plants, pasture composition and animal output.

Low stocking rates [SR] were nominated, by research agronomists especially, as a main constraint to improved pasture output. Increasing the SR would, they said, have an immediate and significant impact on animal production. Even accepting that a high SR would increase the risk of system instability, they argued that SR could be increased considerably - one even suggested that it could be doubled - with few problems. We have no doubt that the transfer of present knowledge on optimum pasture management, including information on SR, to many farmers through extension activities would provide an opportunity to significantly boost animal production. A start could be made by consolidating and publicising the available information on managing production risk and market risk at high stocking rates.

Botanical composition

Review participants showed a varying level of concern on the botanical composition of pastures in the HRZ, particularly the proportion of native species ingressing into improved swards. Some increase in the native species present in such pastures over time is inevitable and the importance of appropriate fertiliser and management policies in reducing this change in botanical composition is generally well understood. However, the long-term reduction in pasture productivity in improved pastures on the central and southern tablelands of NSW [Vere, 1998], gives reason for concern. The decline in sheep production in the region seems a consequence of reduced productivity in the legume-based swards, which represent the bulk of improved pasture in the region.

Further investigations [Vere *et al.*, 2001a] have demonstrated increased production on introduced grass pastures on a range of rainfall-soil fertility environments on the south-eastern tablelands of NSW. In most environments, and in both short and longer-term, the highest economic returns have come from introduced grass pastures. Whilst good economic returns were also generated on both introduced legume pastures and high quality native species, persistence of legumes is a recognised constraint. Over time, returns from good native pastures compare favourably with introduced legume pastures and were better suited to acid soils than the perennial grasses. Relatively poor economic returns were produced from poor quality native species in all environments, the main pasture found in less favourable growing conditions in the region [Vere *et al.*, 2001b]. Further studies on native pastures showed those dominated by high quality species to yield good economic returns under a sound management strategy [Vere et *al.*, 2002].

In addition to the negative effects of poor white clover persistence on pasture production, Vere"s conclusions probably also reflect the levels of input and, in pastures based on exotic species, the stage of their development. Poor native pastures would represent the lowest input systems and pastures dominated by perennial grasses the highest. In addition, these latter pastures would have passed through a legume-dominant phase in their development, a phase not reached in legume dominant pastures because insufficient fertiliser had been applied. In any case, opportunities exist to better understand the causes of the differing performances on the various pasture types, and to develop management policies to obtain a more desirable pasture composition and thus improve animal output.

Sustainability

Pasture sustainability and related environmental degradation are important now; they will become even more vital issues in future years. This is clearly an important area that, we believe, should be of high priority for MLA investments. Our recommendations on the project[s] that might be supported are dependent on the proposed Sustainable Grain and Grazing Systems decisions, on both the focus of the program and the responsibilities agreed between the R & D Corporations committed to its implementation.

In addition, we believe some support should be provided to collect data from long-lived pastures. Management decisions needed to maintain stability and prevent or reduce environmental degradation are dependent on such information. It would be possible to design one or more new investigations specifically to gather the data. However, observation or experimental plots already in existence, e.g. those used in the SGS study and/or as part of the LIGULE investigations, or even long-lived farmers" paddocks, could be used to collect information on, and benchmark, such indices as botanical composition (reflecting both the proportion of desirable species and biodiversity), ground cover, water use, salinity levels and nutrient loss through drainage water.

Weeds

Weeds are of considerable importance in many improved pastures, with a significant number of respondents nominating them as a severe constraint to animal output. Such concerns are reinforced by the quantification, by Vere and his colleagues [Vere *et al.*, (in press)] of losses of pasture production caused by weeds, especially serrated tussock. Both increased plantings of perennial pastures and good grazing management can reduce weeds. In addition, both MLA and other organisations, including CSIRO, have targeted biological control of specific weeds in pastures, and the expected outcomes are promising.

Notwithstanding the major investment already made, with mixed success, to achieve weed control, we believe that removing or reducing this constraint provides an important opportunity. If successful, it would be of considerable benefit in improving the pastures of a large number of red meat producers.

Summary

Our response to Project Objective 2 can be summarised thus : -

° Considerable opportunities exist for improving and sustaining pasture productivity in southern Australia

° They include the provision of better plants, improving the evaluation of new cultivars, raising the level of pasture management, developing optimal managements to improve sustainability and reduce environmental degradation, and improving decision-making

° Particular opportunities include: the selection of improved plants for the WSZ, parts of the HRZ and low input environments; developing an improved protocol for cultivar evaluation; developing agronomic packages for new species; weed control; collection of information from long lived pasture; and, increasing extension activities to hasten transfer of R & D findings

° We do not recommend that MLA invest in all these opportunities, though believe that support is appropriate in projects in the following areas: selecting perennials for productivity and sustainability in the WSZ; selecting grasses for low input environments; developing improved cultivars of perennial pasture plants, using both conventional breeding and biotechnology; assisting in the development of agronomic packages for new species; sustainability and reduced environmental degradation; and extension of research findings to producers of red meat

° We do not believe that the above areas of R & D should all be accorded equal priority. The reasoning for this conclusion, together with some recommendations on specific projects for possible investment, are pursued further in our response to Objective 4.

Analysis of Some Opportunities for R&D Investment
[First page only included to show numbering]
Introduction

Several R&D investment opportunities in the area of pasture plant improvement. Were ubject to analysis via the MLA scoring model. The opportunities selected for analysis include two specific proposals and three rather more hypothetical ones, two in conventional breeding and one in biotechnology. In many respects the opportunities specified are illustrative rather than specific and well-constructed proposals. The analyses results are

therefore indicative rather than constituting a definitive comparative analysis of the best opportunities.

The MLA model was used rather than assessing benefits through individual investment analysis. The model was used for several reasons:

• As well as an investment analysis routine, the MLA model has a subjective scoring module that appeared useful in comparing alternative opportunities across a range of criteria used in assessing prospective projects in other fields of MLA investment, thus providing some cross-comparisons.

•The model already contained significant data about sheep and beef production systems,

• so avoiding the need to assemble a significant amount of common data.

•MLA had only just commenced using the model and the pasture plant improvement applications may have provided an additional perspective on the value of the model and where it might be improved.

On this last issue, the applying the MLA model did prove useful for this purpose. A number of constraints to using the model were encountered. These are identified in an Appendix to this report with the intention of assisting MLA further develop the assessment model.

The five opportunities analysed through the model were:

i. Perennial Species for Dryland Salinity
ii. Evaluation of Low Input Grasses
iii. Improving Persistence in White Clover through Conventional Breeding
iv. Tall Fescue Improvement through Conventional Breeding
v. Reducing the Incidence of Bloat through Biotechnology

The key assumptions made for each of these opportunities and the scores and investment analysis results follow.

The objectives of the project are:
1. Identify and develop new plants that will contribute to increased water use of recharge....

Objective 3. Identify the current capacity in Australia and overseas to undertake pasture improvement work

Public investment in pasture plant improvement

During the past decade, reduced public investment in pasture plant improvement has occurred not only in Australia but in most advanced countries throughout the world. As a result, only two major overseas centres still appear to retain a major public cultivar delivery system. These are : -

1. The Institute of Grassland and Environmental Research [IGER], with Headquarters at Aberystwyth, Wales, which breeds cultivars of ryegrass, white clover and some minor species, and has a relationship with the company Germinal Holdings for their commercialisation, and

2. ETH, in Zurich, Switzerland, which focuses on breeding improved ryegrass and red clover cultivars.

Most other former public-funded programs have become aligned with multinational companies and, as a result, now employ fewer plant breeders than they once did. For example, the Irish pasture breeding program in Dublin is now part of the Barenbrug company, whilst the Hillsborough [Northern Ireland] activities have become aligned with the multinational Advanta. Public pasture plant breeding, into which there had been considerable public investment, no longer exists in the Netherlands and Belgium. Some public boutique [niche] breeding still occurs e.g. in North America, at the University of Guelph, in Canada, and at a number of universities in the USA - usually on contract for private companies.

In NZ, AgResearch [the body which includes the former DSIR Grasslands] no longer undertakes public pasture plant breeding; it has a white clover improvement program in the USA, and undertakes work under contract for a number of private companies. In Australia, though the number of plant breeders has been reduced during the past few years, public breeding is still undertaken in WA, SA, NSW and, on a reducing scale, in Victoria. As of now, there are still worthwhile opportunities for MLA, and other R & D Corporations, to invest in breeding improved cultivars, providing those seeking support can show [i] that the new plants would not necessarily be produced by the private sector, and [ii] have the potential to achieve **real** gains in plant and/or animal performance.

However, the future of public investment in perennial pasture plant breeding in southern Australia appears in jeopardy, unless steps are taken to ensure the survival of at least one improvement program. This could be achieved either entirely by public funding or through the development of long-term alliances between governments and private seed companies for the commercialisation of the new cultivars. The private sector cannot be expected to fund the delivery of niche cultivars with potentially low levels of seed sales.
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Private sector involvement in pasture plant improvement

As public investment in plant breeding has shrunk, so the private sector has expanded its role. This expansion has been so rapid that well over 80% of the breeding of pasture plants worldwide is now undertaken in the private sector. As a general rule, private breeders focus on the production of profitable proprietary products, and their cultivars are said to be more closely related to defined outcomes than many of those bred in the public sector [Coad, pers comm]. In any event, cultivars bred [in either the private or public sector] for uniform growing conditions and high standards of management are more suited to the dairy industry than for the average red meat producer; one seed company executive opined that increased dairy production of 25-30% in Australia was associated with improved cultivars.

Much of the private sector breeding is now undertaken by multinational companies, a list of which is included as Appendix 6. The 4 largest multinationals involved in pasture plant breeding appear to be :-

[i] Barenbrug, with headquarters in the Netherlands. It operates world wide and is involved with the breeding of a range of pasture plants. The Australian company, Heritage Seeds, is part of the Barenbrug group

[ii] Pioneer Hi-Bred, a US-based company, best known for the development of improved lucerne cultivars

[iii] Forage Genetics, another US company, with world wide interests, heavily involved with lucerne

[iv] DFL, with headquarters in Denmark and best known for breeding improved cultivars of *Trifolium*

Large companies either have their own R, D and E programs or have arrangements with other groups to undertake part of this work. For example, Pioneer Hi-Bred, now owned by the US giant Dupont, relies entirely on CSIRO Plant Industry for its pasture plant biotechnology program. Smaller seed companies in Australia do not have facilities to undertake the underlying research necessary for continuing advances in plant improvement.

World biotechnology centres

Genomics [gene sequencing] is invaluable in the longer term to increase our knowledge of which genes control specific traits, and to provide a basis for more understanding of the way genes function. However, much of the work on genomics is geared to gain ownership of IP, on which large multinational companies depend increasingly for their continuing viability. Gene sequencing is very expensive, investigations on plants requiring a team of specialists, including biochemists and agronomists to undertake properly. Nevertheless, the company, Via Lactia, which is associated with the NZ dairy industry, has invested some $150 m to
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search for and capture IP, including some $30 m for gene sequencing in perennial ryegrass.

It is more common for centres associated with pasture plant improvement to concentrate on specific plant traits in an attempt to incorporate valuable characteristics into transgenics through gene transfer from another species or genus. The traits being sought in Australia include: -

bloat resistance in white clover and lucerne, with genes for high tannin content being transferred from *Desmodium*

P efficiency, with genes from bacteria

virus-resistance to the viruses causing alfalfa mosaic virus, clover yellows vein virus and white clover mosaic, with genes from viruses

fructosans from the mouth bacteria [*Streptococcus salivaris*]

tolerance to acid soils [Al tolerance] from yeasts and other Al-tolerant species

nematode resistance in white clover, with marker genes from Caucasian clover [*Trifolium ambiguum*], and

reduced lignin content [one group has abandoned this objective in favour of increased fructosans]

There is considerable and highly reputable biotechnology research in Australia. The expertise available in Australia and NZ covers MLA"s areas of interest in pasture plant improvement. The two largest groups in Australia are at :

(i) the Plant Biotechnology Centre, Agriculture Victoria, La Trobe University, headed by Professor Herman Spangenberg, where the work on temperate grasses and legumes is focused on developing transgenics and MAS, and

(ii) CSIRO, Plant Industry, Canberra, headed by Dr T J Higgins, where the strengths in pasture plant biotechnology lie in developing transgenics

Other biotechnology research on temperate pasture plants is being undertaken at the Waite Institute, University of Adelaide, where Dr J Randles is developing transgenics of medics with virus resistance, with Dr R Rose,University of Newcastle, collaborating in this work.

The major NZ program in biotechnology of temperate pasture plants, being pursued by AgResearch in Palmerston North, covers both the production of transgenics and MAS. The group, within the responsibilities of Dr J Caradus and including Drs D White and D R Woodfield, has developed a particular expertise in the incorporation of transgenics into elite germplasm.

Other major biotechnology groups around the world include :-

[i] IGER, Aberystwyth, Wales, largely interested in transgenics in ryegrass, though with some involvement in bloat

[ii] The Canadian National Research Council, in bloat

[iii] The Noble Foundation in Oklahoma, USA, a large group working on lucerne, particularly lignin and disease resistance

[iv] Dupont [Pioneer Hi-Bred], working with CSIRO Plant Industry on bloat and, earlier, on fructosans, and

[v] Monsanto, focused on herbicide resistance in lucerne

Other key areas in pasture improvement

As previously indicated, there has been a swing away from public investment and an increase in private sector responsibility, not only in plant breeding, but also in other important areas of pasture improvement. During the past decade, as the commitment of state departments to extension activities has decreased, so agribusiness has flourished. Increased technical backup has been a feature of a number of the larger seed companies in Australia, with advice and service being provided not only on seeds mixtures but also on aspects of pasture management. Large agricultural companies have also entered this field whilst consultants have become a source of comprehensive advice on factors affecting pasture output. Seeds mixtures, pasture establishment, fertiliser policy, grazing management, and weed control have all been embraced by consultants. Such has been their influence that Departmental staff have ceased to be the recognised source of advice in some areas of the country. Consultants have been credited with a major role in catalysing change in the pastoral industries e.g. in producers thinking of their enterprises as a holistic system.

Current capacity to undertake pasture improvement

No attempt has been made to undertake a comprehensive analysis of the current capacity in overseas countries to undertake work on pasture improvement. However, consideration has been given to the R & D being conducted in NZ, in order to evaluate its relevance to

work being done in Australia and identify possible areas for cooperation. In many countries, the private sector is assuming an increasing responsibility for work relating to pasture productivity. Not only has this role been influenced by the global thinking and provision of services by multinational companies but also by the private national, regional and local enterprises that have sprung up to provide a range of services. Some of these services have been received enthusiastically by customers, not least red meat producers in Australia.

There are those who argue that the public sector should withdraw entirely from pasture plant breeding, leaving our capacity wholly in the hands of the private sector. However, as indicated earlier, we cannot agree with the view that pasture plant improvement should be left entirely in the hands of the private sector. A case could be made for Australian producers to rely on some pasture plants bred overseas [particularly the ryegrasses, white clover and tall fescue], though we believe that, even then, it should be conditional on their appropriate evaluation in target areas. Pasture output might be little affected in the short-term if public breeding ceased, or even if the number of specialists needed to support such breeding were to be reduced further. However, as one producer put it, in the absence of breeding and associated specialists, „decline [in pasture productivity] is inevitable; problems arise all the time". Another producer commented „if our capacity were destroyed, it would never be restored and we would never be able to respond quickly to a serious pasture problem".

There are good reasons for cooperation between Australian plant breeders and overseas centres, if it results in mutual benefit. For example, during the past decade, there has been very valuable collaboration between the breeders of perennial pasture plants at the PVI, Hamilton, and those at IGER, in Aberystwyth. There is also every argument for close collaboration in pasture R & D between Australia and NZ, particularly in the focus of the research needed to support pasture plant improvement. For example, the extensive basic studies on endophytes being undertaken in NZ should make such work [as distinct from more applied field studies] unnecessary in Australia. Similarly, basic investigations on white clover nematodes appears more advanced than those in Australia, and it would be sensible for such studies to be done in NZ. In contrast, most work on clover viruses should logically be undertaken in Australia, where they are of greater importance. Investigations on plant/water relations are also of greater significance in Australia, with studies on the plant/animal interphase of pastures more appropriately undertaken in NZ, where AgResearch has assembled a team of international standing at Palmerston North.

We applaud the roles of both the public and private sectors in helping increase pasture productivity in Australia. Both sectors have made, and continue to make, many contributions in breeding improved plants, increasing knowledge and providing advice to improve pasture output. We believe that, wherever it is financially feasible, the public and private sectors should co-exist, with perceived quality of service determining their roles.

Yet we are convinced that some R & D ventures can only be undertaken through investment of public funds. Some people may be sceptical about continuing public investment in improving plants that do not have a widespread use for increasing productivity. Yet it is hard to envisage a case against public breeding of plants to ameliorate environmental problems; seed sales of such plants are unlikely to reach a high enough level to attract private investment. We have already argued the case for a continuation of some public investment in pasture plant breeding with a minimum of at least one publicly-funded program, together with associated specialists, having national responsibilities.

In a wider context, there is also an urgent need to increase public investment in science to better understand and help control problems limiting pasture output; many would argue in

similar vein for increasing public commitment to economic and social research that is relevant to both pasture output and the wider rural community. We believe that it is especially important to introduce younger people into what is becoming an ageing group of researchers working in these fields.

The above analysis relates to our response to Objective 3 in the ToR of the review. We are strongly of the view that Australia needs its own capacity to undertake most of the work needed to improve pasture output, reduce environmental degradation and enhance human capacity. The one proviso to this proposition would be that there should be no unnecessary duplication of similar work being undertaken in NZ.

We believe that, as of now, there is probably sufficient capacity in Australia to undertake most of the work needed to improve pasture productivity and reduce environmental degradation. The staff and infrastructure involved in biotechnology appear adequate, though the high cost of the research constrains the choice of work able to be undertaken. The combination of the resources available in the public and private sectors provide a reasonable level of capacity to undertake the R, D and E required for most aspects of pasture improvement. Further, following recent decisions by government and a number of R & D Corporations, considerable resources are being put into measures to reduce environmental degradation, particularly the effects of rising water tables and, in some cases, salinity. Work already underway will also increase the human capacity of producers, enabling them to improve pasture productivity and, hopefully, their income.

We have some concern about the continuing viability of public plant breeding. The reducing level of public support may well become a constraint to future activities unless there is additional investment into public breeding. Our concerns would be further heightened if the resources provided to the DNRE program at Hamilton continue to decline. We also strongly believe that a number of younger staff need to be appointed, not only to assist in understanding problems affecting pasture productivity and the environment, but also to undertake economic and social research, particularly that relevant to the farming industries. We have little doubt that, unless „new blood" is introduced as a matter of some urgency, constraints will soon develop to delay or prevent the achievement of improvement targets.

Summary

Our response to Project Objective 3 can be summarised thus : -

° In a number of advanced countries, including Australia, responsibility for undertaking work in pasture improvement is being assumed increasingly by the private sector, a development associated with reduced public investment

° Multinational companies have become predominant in pasture plant improvement. National, regional or local private companies and consultancies now provide services covering a range of key areas in pasture improvement

° We strongly believe that Australia should have sufficient capacity to undertake the range of work needed for pasture improvement. The only proviso we have is that there should be no unnecessary duplication of work in Australia and NZ

° Within Australia, the present capacity in the public and private sectors is generally sufficient to satisfy the requirements for most work needed on the key areas in pasture improvement, with sufficient biotechnology expertise to cover MLA"s interests in this field

° Some of this work will only be done in the public sector. We have concerns for the continuing viability of public pasture plant breeding and for scientific, economic and social research. Unless there is public investment in such activities, they will become constraints to resolving problems and achieving targets.

Objective 4. Suggest an investment strategy for MLA :
[i] linking pasture plant improvement with other activities in pasture improvement, and
[ii] after assessing constraints and opportunities, indicate key stages to enable the above investment strategy for R & D findings in pasture improvement to be implemented with maximum benefit to the red meat industries

Role of MLA

We perceive that the fundamental role [and thus the core business] of MLA is to act as an agent of change for the red meat industries. In the context of this review, MLA should help achieve change by (i) gathering and promoting innovative and objective information on the animal feedbase, and (ii) encouraging producers to adopt this new information in their pasture system, even though this may require major changes in their management practice. Investments should therefore be made in targetted projects perceived to result in major and continuing benefits to the red meat industry. These benefits - improving pasture output and making production more efficient - should increase the competitiveness of the industry in Australia and overseas. We believe that MLA could, and should, be the investment driver for at least some of the projects within this core business.

Criteria used for selecting investment opportunities

Our suggested strategy for future MLA investment in pasture improvement in southern Australia has been developed within the above context. It is designed to achieve what we perceive to be the most effective use of the available funds to provide maximum benefit - in both short and longer term - for the red meat industries. The funds available for annual investment [which we believe to be between $2m and $3m], though substantial, are insufficient for MLA to take sole responsibility for funding major and continuing programs. Investment should be focused on the support of projects, with specific objectives, for a limited period, and for leverage of funds from other bodies.

Results from MLA-supported projects in pasture plant improvement, evaluated earlier [see p 7-20] have been used as a significant factor in developing our recommendations. Specifically, we considered whether MLA should [i] continue to invest in pasture plant improvement, and [ii] invest to help achieve the potential of those cultivars from the projects supported by the Company.

We strongly recommend that MLA continue to fund pasture plant improvement. Pasture plants are fundamental to output in the red meat industries. Considerable and continuing gains in productivity are being made by selecting and breeding improved plants, especially in the WSZ, whilst there is potential for improved plants, especially legumes, in the HRZ. It is important to maintain capacity for plant improvement in Australia, particularly with species such as subterranean clover and phalaris where developing improved cultivars is dependent on our own efforts. Further, the increasing importance of sustainability, environmental problems such as salinity, and commercial issues e.g. the requirement for minimum seed sales for viability and IP, provide opportunities for MLA to support [as distinct from being the prime funder] pasture plant improvement in both the public and private sectors. No simple strategy can be recommended for investment in pasture plant improvement. A clear set of

guidelines are required [see p 102] against which possible investment opportunities can be evaluated as they are identified.

While the marketing of new varieties is essentially a commercial matter, MLA has good reasons to invest in unlocking the constraints which restrict the use of improved cultivars and prevent the realisation of their full potential. MLA investment in a number of extension projects would help achieve these objectives; opportunities for such investment are discussed later [see pp 93-96].

In determining the areas in which to invest, we believe that MLA should consider the likely impact of all the factors potentially important in affecting animal output from pastures. Our judgement is that large and continuing improvements are most likely if MLA adopts a balanced portfolio of investments, with some providing short-term gains and others longer-term benefits; the extremes are typified by extension activities (short-term gains) and biotechnology (potential long-term benefits). We have recommended a split in investment between projects in plant improvement and those in other activities with a potentially large impact on pasture output.

All the opportunities we have recommended for investment fall within the R & D programs adopted by MLA for the red meat industries. They all satisfied at least one of the „Triple Bottom Line Outcomes", i.e. judged likely to have a positive impact on at least one of the Financial, Environmental and Social outcomes detailed in the MLA Lamb and Sheepmeat R & D Program [August 2001]; some of the opportunities recommended satisfied all three objectives.

We considered that opportunities with national objectives were generally more worthwhile for investment than locally-focused proposals, as we did those with both a productivity and an environmental objective. This environmental criterion [i] reflects our feeling that agricultural and environmental interests should become more coincident, and [ii] takes into account a major interest of the Commonwealth Government, the joint funder [along with red meat producers] of MLA activities. We also felt that our proposals should assist the development of human capital, and we have recommended investment opportunities both to increase the knowledge and skills of producers and augment the numbers of post-graduate students in relevant fields.

To a greater or lesser degree, the level of funding already available to pursue all those opportunities that we have recommended for MLA investment acts as a constraint to the achievement of their objectives. In a number of cases, delivery of outcomes would take longer in the absence of MLA funding; in some instances, lack of investment that could be used for leverage may prevent a project being undertaken.

Recommended criteria to determine MLA's investment strategy

The primary objective of MLA"s investment strategy - to maximise benefits to the red meat industry, in short and long term - requires support of both work to reduce constraints to productivity and that which addresses environmental issues

Projects supported should be compatible with the objectives and priorities of the R & D programs adopted by MLA for the red meat industries

MLA should continue to invest selectively in plant improvement as part of a portfolio of support for R, D & E covering major constraints to pasture improvement. Work designed to unlock the constraints which restrict the use of improved cultivars developed in the MLA projects and prevent the realisation of their potential should also be supported

MLA should not be the sole funder of major and continuing programs. The main focus of its investment should be in specific short-term projects with clearly defined objectives, sometimes as part of a long-term investigation funded by other bodies

Collaboration should be sought with other bodies to develop proposals for investment in work with common interests. MLA should be proactive if necessary in promoting investment opportunities, using the Company"s commitment as leverage in seeking funds from other potential funders

Investment opportunities in pasture improvement

Investment in improving pasture plants [selecting new species, breeding improved cultivars and biotechnology] is considered under opportunities 1-5, with that in other activities in pasture improvement presented under numbers 6-9. Numbers 10 and 11 are important opportunities for investment in related areas. Some of the opportunities which we have suggested for MLA investment are discussed in more detail than others. Sometimes, these were potential projects where we had been made aware of a submission for support which either had been, or will be, made to MLA. We also felt it was presumptuous to recommend specific projects for investment where the Company has continuing funding commitments [e.g. in weed control] or in areas which MLA has already decided to invest [e.g. in sustainability through support given to the Sustainable Grain and Grazing Systems Program]. Investment proposals falling into these categories are discussed in brief only.

Opportunity 1. Selecting perennial and salt tolerant species for dryland salinity

This nationally-coordinated proposal seeks to identify deep-rooted perennials and salt tolerant plants to address environmental problems associated with salinity in southern Australia. The extent of, and predicted increase in, salinity in WA and the Murray Darling Basin have already been described briefly; so too have the effects of salinity on individual farmers and the wider community, and the methodology proposed to address the problems [see p 57]. In addition, the proposed project has been selected as an opportunity for investment and subjected to the MLA scoring and investment analysis model [see p 69-71]. There can be no doubt of its importance for the red meat producers.

The proposal, focused on sustainability, would be undertaken by the CRC for Plant-based Management of Dryland Salinity, headed by Professor Cocks, an agricultural scientist of international standing. Professor Cocks has already had a major impact in changing the focus of pasture plant improvement in WA. The CRC would also provide an excellent opportunity for post-graduate study for one or two students.

In addition to limitations imposed by the level of funding, the other likely constraint is the relatively narrow gene pool presently available to provide the plants suitable to achieve the desired outcome. Focused plant collections from targeted centres of diversity would widen the genetic base of material available for selection and thus probably increase the chances of selecting species better suited to combating salinity.

This proposal, including the support of post-graduate students, represents a genuine opportunity for investment. We strongly recommend that it be accorded very high priority for MLA support.

Opportunity 2. Selecting perennial grasses for low input systems

We support the proposition that there should be some investment in low input plants and systems, as an opportunity to both increase pasture productivity and reduce environmental degradation. We had some difficulty in nominating a priority area for any such investment, especially as the opinion of review participants was evenly divided on whether domestication of native species or ecological and management studies influencing diversity should be the first step in the study. We have chosen to recommend the first option, namely the proposition to evaluate and select plants for low input systems. Whilst it could be argued that governments should take the initiative in the study of diversity, the more cogent reason for our decision was the successful low-cost MLA project [TR 045]. This national study, involving government agencies in 5 states, resulted in the collection of worthwhile data on the spaced plant performance of almost 60 populations [native and exotic] at 9 sites throughout southern Australia.

Details of the project to select perennial grasses for low input systems, including the proposed methodology [much of which is developed from that used in TR 045] to evaluate persistence and performance in grazed swards, seed production and establishment of populations which showed promise in TR 045, have been described [see p 58-59].

There is some risk that the time frame proposed will be insufficient to achieve the projected outcomes. Problems with seed production and pasture establishment of the native species [as distinct from the low input exotics] that performed well in TR 045, could be a further constraint. Nevertheless, we believe that the proposed project, which has also been subjected to the MLA scoring and investment analysis model [p 71-73], could be beneficial to producers of sheepmeat and store cattle and make a positive impact on productivity and sustainability. We believe that it represents a genuine opportunity for MLA to invest in the work, and we so recommend. In the absence of such MLA support for leverage, we doubt whether any of the other bodies likely to participate in the work will take the initiative to obtain the necessary funds.

Opportunity 3. Selecting perennial legumes for the Northern Tablelands and NW Slopes of NSW

The lack of a persistent legume has been a major constraint to the productivity of the improved pastures on the Northern Tablelands and NW Slopes of NSW. There is no doubt that finding one or more legumes, with significantly greater persistence than the white clover cultivars presently available and able to perform well in tablelands pastures, would provide an important opportunity to improve longer term productivity. A positive impact on both economic and environmental stability could then be predicted with some confidence.

There appear three approaches for pursuing the desired outcome, namely to : -

[i] Attempt to breed more adaptable and drought resistant white clover cultivars (A scenario for breeding white clover with increased persistence has been subjected to the MLA scoring model and benefit:cost analysis as Opportunity 3 [see p 73-74].

[ii] Undertake further evaluation of the performance of the „bloat-free" species of *Lotus* under a variety of growing conditions and managements, and

[iii] Evaluate a broader range of legumes

It is pertinent here to consider the relative likelihood of achieving significant gains either by attempting to further improve white clover, a plant nearing the limits of its adaptive range on

the Northern Tablelands and NW Slopes, and „thinking outside the square", i.e. searching for other species better able to persist and perform well under the prevailing conditions. There are examples of some success being achieved from both approaches, thus providing an argument for continuing to evaluate both. Our conclusion is that some increase in the drought resistance of white clover would probably be achieved by breeding. However, how any such increase would affect the plant"s overall persistence on the N Tablelands and the NW Slopes is uncertain. More general improvement in performance could be achieved from further investigations on lotus, though the extent of its adaptability to a range of growing conditions and management remains an open question. If there has to be a choice of which single approach should be supported, our judgement is that the evaluation of a broader gene pool of legumes provides the best opportunity for selecting one or more legumes that persist[s] and perform[s] well on the Northern Tablelands. We are reinforced in our conclusion by the success achieved in seeking a similar outcome in Tasmania.

The above options could all result in disappointing progress being made to achieve the desired outcomes. This risk has to be a constraint to the proposal. Nevertheless, selecting at least one legume that performs better than the white clovers now available presents a real challenge. If the objective could be achieved, it would be of great benefit to the sheep and beef producers on the Tablelands. Although the area of pasture with improved productivity may be smaller than that under Opportunity 2, the total increase in output could well be greater. We thus recommend the above proposal as a worthwhile opportunity for MLA investment.

Opportunity 4. Conventional pasture plant breeding

Examples of improved cultivar performance resulting from conventional breeding have been detailed earlier. Suffice to say that, in addition to increased persistence, plant traits such as significant improvements in quality, major increases in out-of-season growth, resistance to serious pests and diseases, elimination of toxic substances and increased tolerance to adverse soil conditions could all result in worthwhile positive outcomes for the producer. These objectives all appear achievable through conventional breeding. Further, elite high-yielding forages with enhanced quality could be produced for high performing systems. It should also be possible to breed for desirable physiological traits such as increased efficiency in the uptake of nutrients, and perhaps in water use, both of which have implications for the environment.

MLA has invested substantially in two successful pasture plant breeding programs, namely the perennial grassbreeding program in Victoria, and the lucerne improvement program in SA. We recommend that MLA continue to invest in pasture plant breeding and, as an example, have used the MLA model to assess one such scenario associated with breeding for improved tall fescue [Opportunity 4 - see p74-76]. We have already indicated our preference for investing in a specific project, rather than providing general support for the core program. Whilst we have deliberately refrained from promoting a specific project for support, we recommend that any investment should be conditional on MLA being satisfied that there would be sufficient gains in the performance of the new cultivar[s] to enable positive impacts for producers.

It has been argued that the slow rate of genetic gain in yield through conventional plant breeding is an important constraint which undermines the case for investment. We reject this proposition. Even if a counter argument were based entirely on an annual yield gain of 0.75 to 1% [there is no evidence of any reduction in this rate], a decade of such gains would both equal the estimated improvement of some biotechnology advances and be achieved with less risk. Further, a case based only on yield gains would be an over-simplification. It does not take into account the considerable improvements achievable by conventional

breeding as a result of improving the traits listed in the first paragraph of Opportunity 4, above.

Conventional pasture plant breeding represents a continuing opportunity for MLA investment. Subject to the proviso listed above, we recommend that further funding be provided to at least one of the two programs previously supported by the Company.

Opportunity 5. Biotechnology

The value and limitations of biotechnology and its inter-relationship with conventional plant breeding in the delivery of improved cultivars have been covered earlier in this report [pp 52-55]. Notwithstanding the constraints - risk, time delays and public attitude to GM plants - we believe that the considerable potential benefits of transgenics will be realised ultimately.

While we recommend a continuing investment in biotechnology, we have some concerns about the progress made in the biotechnology project on bloat-free legumes, on which MLA has invested more than $2m. We do not rate continuing investment in this project very highly, but accept that MLA may have some difficulty in „walking away" from this investigation. We further appreciate that the Company may feel it necessary to continue to support some work in biotechnology and a scenario for „Reducing the incidence of bloat through biotechnology" has been subjected to the MLA scoring model including a benefit:cost analysis (Opportunity 5) [see p 76-78].

Relative funding of biotechnology and conventional breeding

The fact that transgenics have to be incorporated into a conventional breeding program before their benefits can be realised through the delivery of new cultivars needs to be taken into account in any consideration of investment in conventional breeding and biotechnology. Our recommendation on their funding has been influenced by the opinions of biotechnologists. All stressed the importance of funding conventional breeding as well as biotechnology. For example, one said "the current deficiencies in pasture plant improvement are that the government, state and industry funding has moved almost exclusively to the biotechnology end of the spectrum, leaving the seed industry to be the predominant funder of pasture plant improvement in Australasia..... while I understand the potentially greater economic returns from a major breakthrough, I believe a more balanced portfolio is required maintaining capabilities in conventional breeding will be absolutely critical to the ability to capture benefits from biotechnology, at least for animal based industries". He went on to comment "Directing all funding to biotechnology would be extremely short-sighted. Integrated teams will be the winners long-term".

Turning to the funding balance between the two components of pasture plant improvement, another eminent biotechnologist, after stressing that „conventional breeding is very important in delivering genetically modified cultivars" said „I would probably suggest a split of 30% to biotechnology and 70% to conventional breeding - perhaps 40% : 60%, but certainly no higher". All who proffered an opinion focused on the importance of balanced funding between biotechnology and conventional breeding, the proportions suggested varying from 30% to 60% for biotechnology [the person nominating this latter figure "not because biotechnology is more important, but because it is more expensive"] and from 70% to 40% for conventional breeding.

There might be some logic for a strategy that DRDC/DNRE allocate all their future funding of pasture plant improvement to biotechnology. The dairy industry is well served by NZ varieties and breeding in the private sector. However, this situation contrasts with that for the sheepmeat and beef industries. The pasture management systems characteristic of

these industries cover a wider range of climates and soils, and are generally more extensive, than those of the dairy industry. This broader focus, taken together with the undoubted public good component of government breeding programs, make it essential that some of the funding allocated for pasture plant improvement should be directed to conventional breeding.

In allocating funds for the two options, we recommend - as a guide not a prescription - a split of 40% to biotechnology: 60% conventional breeding. Yet we cannot envisage any circumstances where the total allocation of funds for biotechnology should exceed the level of support provided for conventional breeding. While we might lean to investing in MAS ahead of transgenics, because of its potential reduction in the length of the breeding cycle, both have a role in pasture plant improvement. We see little value in recommending relative levels of funding for transgenics and MAS; any such recommendation would be too restrictive and would „straight jacket" MLA in determining the projects in which to invest.

What we would particularly favour is investment in work integrating the potential contributions of biotechnology and conventional breeding in cultivar delivery, if a suitable project were able to be developed. For example, use might be made of MAS in breeding for an important trait such as improved herbage quality or the elimination of a toxic substance, making selection more certain and reducing the length of the breeding cycle. Alternatively, transgenics already available, e.g. legumes with virus resistance, might be incorporated into elite germplasm in an effort to keep the breeding cycle as short as possible.

Extension activities

There is clear evidence, reinforced by information gathered during the review, that the level of scientific and technical knowledge of factors affecting pasture output is generally way ahead of its application. Thus, in common with review participants, we strongly support an increased MLA investment in extension, which could cover a range of factors potentially important in their impact on pasture output. It could also include supporting work on factors constraining the adoption, and restricting the realisation of the potential, of cultivars from MLA projects [see pp 86-87] The challenge in extension is not only to supply information, but also to assist producers find, interpret and use what is available. We have no doubt that such investment would result in considerable improvements in pasture management and output; reduce environmental damage; and increase the skills base of producers. The fact that all three "Triple Bottom Line Outcomes" could be achieved reflects the importance of the proposal and provides a real opportunity for significant MLA investment. We believe that considerable gains accruing from the investment are almost certain, with no obvious constraints, providing total funding levels are adequate.

Opportunity 6. A National Decision Support System

The objective is to develop, co-ordinate and implement a national decision support system [DSS] to help red meat producers in southern Australia develop and utilise productive and sustainable pastures. This requires: -

[i] The assembly of information for an agreed set of industry protocols and benchmarks for the establishment, assessment, management and utilisation of pastures for the HRZ and WSZ

[ii] Consultation with researchers, educators, advisers, agribusiness and producers in the use of the protocols to achieve industry benchmarks for the productivity, sustainability and profitability of pasture/livestock systems, and

[iii] A national launch of an integrated DSS, using the latest extension techniques to achieve a self-sustaining network

The industry protocols would be based on a number of successful projects and programs, such as the Prime Pasture Project (NSW Ag) for pasture establishment, Pasture Check (GRDC TOPCROP) for pasture monitoring, the Temperate Pasture Sustainability Key Program (TPSKP) and SGS programs (MLA) for sustainable pasture management, PROGRAZE (NSW Ag) for pasture and livestock management, the Grassland"s Productivity Program (Grassland Society of Victoria), GrassGro (CSIRO) and the Farm Monitor Program (DNRE) for generating pasture targets and decision support. The existing information needs to be remixed so that it is presented simply and consistently for a national audience. Separate information/training packages are needed for the HRZ and the WSZ, but much of their content could be common. Both could be available as printed manuals, for a fee, and on the world wide web.

The training program could be provided as a self-teaching version [book, manual and web], or as a modular short course available through vocational courses or advisers. The modules could include deciding on an approach (likely outcomes and risks from low-, intermediate- and high-input strategies), selecting pasture species and cultivars for different climates and soils, pasture monitoring & management (soil, weed, pest and disease monitoring, botanical composition and other pasture checks) for production and sustainability, and utilising the pasture for profit (stocking rate, livestock production, destocking/restocking decisions, economics).

We envisage that the program would require a national coordinator, regional „champions", an advisory panel, contract writers and designers, together with funding for pilot testing, materials, travel and publication of results. MLA support could provide invaluable leverage for obtaining investment of public and private sector funds, whilst other R & D corporations may also wish to be involved in the proposal. Specific responsibilities, including funding commitments, of participating bodies would need to be negotiated.

We have no doubt that the proposal would result in very positive impacts on all three “Triple Bottom Line Impacts”. We see no obvious constraints to it getting underway, except perhaps the level of commitment of state instrumentalities and agribusiness. We recommend the proposition as a very important opportunity for MLA investment. It falls into our highest category for support.

Additional investigations associated with the suggested National Decision Support System

Further work is needed in two areas related to the proposed national DSS, namely in: -

[i] Development of management packages, and

[ii] Extending the use of GrassGro. It is envisaged that data collected from these two proposed projects would be integrated into the national DSS.

Opportunity 6a. Development of management packages

Management information packages, listing best practice, need to be assembled and available at the time of release of key pasture types and new species. This is especially necessary for the new legumes now being released for the WSZ. The same requirement would be needed for selected populations of native species,that also require specific management practices to persist and perform well. Some of the information needed for

designing, coordinating and launching such packages as part of an integrated DSS is already available. In this context, the co-ordination and promotion of GRDC"s TOPCROP monitoring package, which was the first attempt to integrate a range of monitoring tools and protocols for a national farm audience, is especially relevant. DRDC has also invested regionally in the extension of relevant pasture information.

Even where there appear only small differences between relatively newly introduced plants and other commonly used species, inappropriate management can result in negative publicity. For example, the difficulty in managing tall fescue/white clover pastures to maintain an acceptable legume content [coupled with the poor seedling vigour and the low digestibility of the tall fescue cultivars first introduced into Australia] resulted in the grass having a poor image and in its slow adoption. It is only during the last few years that better information on optimal management of tall fescue, coupled with its greater tolerance of both moisture stress and higher temperatures than perennial ryegrass, has resulted in it becoming more widely appreciated. This increased knowledge of the plant and the realisation that achieving its potential is dependent on appropriate management, have been responsible for the considerable recent increase in seed sales of tall fescue.

We do not believe there are significant constraints to implementing this proposed project, other than the level of funding that might become available for the suggested work. We strongly recommend that MLA invest in this proposed project that we regard as a high priority area for support. In addition to the funding which MLA might provide, we think that there should be public investment in a proposal which has the potential to make a very significant impact on the red meat industries. It is possible that other R & D Corporations might also wish to participate. Negotiations would be needed to determine the responsibilities and financial commitments of the participants. As with the project for a National DSS, such benefits would quickly follow the start of the work.

Opportunity 6b. Extending the use of GrassGro

GrassGro has been used in recent years to provide pasture and animal data for farmers and graziers in NSW. One exercise, which involved estimating the monthly growth of various pasture types in several regions of the state, provided invaluable data for making decisions on feed budgeting. The extension of such work to cover key pastoral areas throughout Australia would enable the development of seasonal benchmarks for pasture growth, pasture biomass and animal liveweights at recommended stocking rates. This information would put decision-making on feed budgeting on a more rational basis than the current practice in many parts of the country.

We thus strongly recommend that GrassGro, an integral part of the proposal to develop a national DSS, should be extended Australia-wide to improve feed budgeting in the red meat industries. It would find a use in both those parts of the HRZ where the DSS has not been available and in the WSZ. We recommend the proposal as a high priority opportunity for MLA investment. Comments on funding and benefits made for Opportunity 6a apply equally to this proposal.

Opportunity 7. Botanical composition

Studies on the Northern Tablelands of NSW, undertaken some 30 years ago [Wolfe and Lazenby, 1973 a, b] showed that the rate of development of newly improved pastures, and the stage that such development reached, depended on the fertiliser regime. These studies are germane to the findings of Vere and his colleagues [Vere et al. 2001a, b; 2002] that showed the botanical composition of pastures dominated by both native and exotic species to be associated with the level of their economic returns.

One research agronomist participating in the review advocated the use of seeds mixtures with a wider range of species than normal so that the plants could occupy the different ecological niches characteristic of most pastures. In any event, in improved perennial pastures, a decline in the proportion of sown species over time, and an associated increase in the content of native plants, appear inevitable. An acceptable level of natives can normally be maintained given appropriate fertiliser and grazing regimes.

We believe that further ecological and management studies are needed on a range of pasture types in order to [i] better understand the causes of the changes in botanical composition in a number of pasture types, and [ii] develop management practices which will result in a more desirable pasture composition and thus improve animal output. We believe such work provides an opportunity for MLA investment.

Opportunity 8. Sustainability studies

The case for an increased focus on sustainability studies has been made and widely accepted in Australia. Some of the recommendations that we have already made as opportunities for MLA investment - particularly Opportunity 1 but also Opportunities 2 and 6 - have an important sustainability component. Further, we understand that MLA has already taken the decision to invest major funds into sustainability R & D through its commitment to the SGGS. We can only applaud this decision, having already concluded that investment in work on sustainability should be a high priority. Because major MLA investment in sustainability appears assured, we have decided not to promote any specific proposals for further R & D in this field.

However, we would strongly urge that MLA make some investment in collecting a range of pasture indices over a long time frame. This information is essential to quantify and understand the relationship between such indices and productivity, sustainability and degradation. Such a venture, which we believe to be of very high priority, need not be expensive if use could be made of long-lived plots or even farm paddocks that are already in existence.

Opportunity 9. Weed control

Weeds represent a severe constraint to pasture output, and are thus an important opportunity for investment. We understand that MLA has already invested heavily in weed control, particularly biological control of specific plants. We support continuing major funding in weed control as a high priority, but have not nominated any specific project for further support because of the continuing commitments that we believe MLA has in biological control. Weed control is a large and complex field of study and, when considering additional investments, it is clearly in MLA"s interests to invest in R & D which has the potential to significantly improve pasture productivity of red meat producers.

One of the potential constraints to achieving a significant impact from the large MLA investment in biological control of thistles and Paterson"s Curse is the integration of biological control needs into pasture and grazing management practices, as well as with other specific weed control practices. In this respect, some of the further investment in weed control could be via investment in Opportunity 6.

Opportunity 10. Funding post-graduate scholarships

Reference has already been made to the need for „new blood" in the R, D and E work needed to increase pasture productivity and sustainability. We believe there is a genuine

opportunity for MLA to contribute to this objective by funding a number of post-graduate scholarships. Opportunities exist to support post-graduates to undertake studies associated with the selection or breeding of improved pasture plants e.g. at the CRC for the Plant-based Management of Dryland Salinity, attached to one of the successful breeding programs already supported by MLA, or to a biotechnology centre. Scholarships could also be provided for post-graduate study in agricultural economics [or farm management] and in rural sociology at one or more Australian universities, a number of which have an international reputation in these fields. We strongly support post-graduate studies in the above areas and urge MLA to fund a minimum of three post-graduate scholarships, one in each of the fields of agricultural science, agricultural economics/farm management and rural sociology.

Opportunity 11. Modelling studies

Quantitative studies undertaken in the dairy industry and broadacre agriculture in Australia [Scobie *et al*, 1991, Mullen and Cox, 1995] have shown the impact of investment in R & D through changes in productivity. We suggest that MLA consider undertaking similar studies on the impact of R & D investment on farms which more centrally reflect productivity in the red meat industries.

Qualitative associations have been shown between R & D outputs and productivity changes in a number of agricultural industries in Australia, including dairying and grains [Chudleigh and Simpson, 2001]. In dairying, Riley *et al* [1999] attributed the increase in milk yield per cow, and in the protein and fat content of the milk, to 4 main factors, of which one was pasture management. We recommend that MLA consider attempting to relate - at least qualitatively - productivity growth in the red meat industry to a number of factors. We believe that such a study could be a valuable opportunity to shed light on the past relative importance of pasture management in raising productivity.

Specific recommendations for MLA investment

Although there were improvements which could be made to the process we used to determine our recommendations for work in which MLA might invest [see later], we are confident that we have identified the main factors limiting the outcomes and sustainability of the feed base for the red meat industries in southern Australia. We have used this information as the basis for making recommendations on investment opportunities.

Having considered at length the likely impact of the various opportunities identified, we propose that some 35% of the MLA funds available for investment should be allocated to projects designed to select or breed [using conventional methods and biotechnology] improved pasture plants. This would leave around 65% of the funds to support projects in other key areas of pasture improvement. By way of illustration, if $2m were available for overall investment in pasture productivity and sustainability, we recommend that about $700,000 be used to support plant improvement projects and some $1.3m for projects addressing other limitations to pasture performance. Similarly, following our earlier recommendations, and including Opportunity 1 in our calculations, we do not recommend allocating more than $280,000 - as an upper limit - to work in biotechnology. This would leave a minimum of $420,000 to invest in the selection and conventional breeding of improved pasture plants. The proposals for apportioning investments do not include : -

° support for work on Sustainability in the SGGS, in which we understand MLA has already decided to invest

° the continuing funding of investigations on Weed Control, and

° modelling studies, which we feel should be supported from other MLA funds

We strongly support investment in these three areas.

We are convinced that the programs/projects that we have identified are all excellent opportunities for investment. MLA could support every one of them with confidence of a positive impact on at least one of the "Triple Bottom Lines" which the Company has identified as required outcomes. We believe that two stand out as the highest priority for funding, namely: -

° Extension activities
Opportunity 6 - A National Decision Support System, and the associated
Opportunity 6a - Development of Management Packages, and
Opportunity 6b - Extending the use of GrassGro

° Problems associated with salinity
Opportunity 1- Selecting perennial and salt tolerant species for dryland salinity

Extension activities would provide positive impacts soon after investment, with benefits following investment in Opportunity 1 taking a little longer to become evident.

We reiterate our belief that MLA should support as many as possible of the other areas selected as investment opportunities, namely : -

Funding post-graduate scholarships	Selecting perennial grasses for low input systems
Conventional pasture plant breeding	Biotechnology
Selecting perennial legumes for the Ecological and Management studies	Northern Tablelands and W Slopes of NSW

Perceived role of MLA in different scenarios

Brief comment can be made on possible changes in the role of MLA which we we think might occur under a number of scenarios, together with some impressions of their consequences. For example, in the event of public investment in pasture plant breeding being withdrawn - a decision which is the responsibility of government - we reiterate our view that it is not the role of MLA to fund long term programs. Thus we could not advise MLA to either assume sole responsibility for any such programs or even continue to invest in specific projects.

In contrast, if public funding for management [interpreted broadly] were to cease, we would recommend an increased investment in such activities. We envisage MLA playing a major role in identifying and promoting the importance of investing in the solution of problems in areas seen as important constraints for the red meat industries. We also think the Company should be proactive in seeking to develop collaborative investment in targetted projects with other RDCs and the private sector, including consultants.

In a scenario where all the pasture plant breeding was undertaken by the private sector, we believe that it would be restricted to commercially viable programs. We thus believe that MLA should invest in projects perceived to provide major benefits to the industry.

We reaffirm our strong view that MLA should continue to invest in targetted projects in plant breeding. Withdrawing all support for such cultivar improvement would deprive the Company of the opportunity to help achieve and hasten major increases in pasture output which we are convinced are still possible from targetted breeding of better performing varieties.

We have argued strongly for MLA to have a portfolio of investments, some to provide benefits quickly for the industry and others for major longer-term gains. We are sure that it would be a mistake for the company to invest solely in platform technology. Not only would it result in no tangible short term benefits for producers, but there would be an increased risk of achieving little or no gain. Further, we doubt whether investing only in platform technologies would allow the Company to fulfil its core responsibilities, and believe it would call into question the producers" view of the value of MLA to the industry.

Investing only in management would result in short-term benefits, perhaps greater than would flow from the more balanced investment we have recommended. However, such a decision would leave nothing „in the pipeline" to provide longer-term benefits expected to flow from a number of the projects we have recommended for MLA investment in pasture plant improvement.

Developing and implementing an MLA investment strategy

Choice of project

The process that we adopted to canvass the views of stakeholders on limitations and opportunities for investment in pasture improvement and sustainability could have been more complete in two respects. First, we did not have detailed discussions with representatives of all relevant state bodies. These might have enabled us to determine the states" priorities for R, D and E in pasture productivity and sustainability, and it is conceivable that they would also have revealed their broad financial commitment to such work. Secondly, despite several attempts, we were unable to contact AWI. This was unfortunate as we felt that AWI representatives could have made an important input into the review.

Although we are confident in our recommendations for MLA investment on this occasion, we believe that a more permanent structural arrangement should be put in place as the first step in determining the responsibilities of government, R & D Corporations and the private sector in the R, D and E needed in pastoral and related fields. We are strongly of the opinion that it would be in Australia"s interests to establish a body or standing committee that would meet at least annually to [i] review, on a national basis, the needs for R, D and E in pasture productivity, sustainability and associated environmental problems, [ii] determine national priorities for investing in the opportunities identified, and [iii] agree on the responsibilities of the participating groups to undertake and/or invest in the national program. We anticipate that broad agreement could be reached resulting in the various parties collaborating in investigations affecting their major shareholders, ensuring that there was neither unnecessary duplication of investment by the public sector and by the RDCs, nor any omission of major problem areas.

We envisage the composition of the body, which could report to the Pasture Improvement Committee [PIC], would include representatives of [i] the Commonwealth and State governments, [ii] relevant R & D Corporations [AWI, DRDC, GRDC, LWA, MLA, and perhaps RIRDC], and [iii} Agribusiness.

We applaud the measures which MLA has taken to develop the Strategic Plans for the Lamb and Sheepmeat industries and for the southern Australian Beef Program. They demonstrate the determination of the Company to obtain genuine input from producers. We believe they are entirely appropriate steps, and recommend that similar measures be taken when MLA develops future strategic R & D plans.

MLA already has a process under development for evaluating prospective projects, using scoring and incorporating a standard benefit:cost model component. This process, including the model component, should be further developed. Notwithstanding the reservations that we have on this benefit:cost component [see Appendix 5], MLA should be commended for initiating this approach. Where there are large projects or long-term investments, independent benefit:cost analyses could be undertaken to provide another input to enhance the decision making.

It would be worthwhile MLA considering setting up an advisory group to assist in the choice of specific projects for investment. It need not be very large and could include one or two representatives of producers [perhaps from regional committees established for the SGS program], researchers, extension workers and agribusiness, as well as senior MLA staff.

Having decided where it might invest, we anticipate that MLA would seek expressions of interest for undertaking the work on the chosen topics. We would suggest that the bulk of the available funds [say 85%] be used for support of projects within these topics, leaving a small proportion for supporting any other proposals considered worthwhile for MLA investment. We believe that the Company should reserve the right to ask those who have not made applications, to undertake the work, and to negotiate to use the resources of more than one group should this be in MLA"s best interests.

Recommended criteria for choice of investment projects

Proposals should be clearly focused, with objectives achievable within an agreed time frame, and score well in a benefit:cost analysis

Projects likely to have the biggest impact on the red meat industries be given high priority, especially if it is perceived to have positive effects on more than one of the „Triple Bottom Line" outcomes

Projects of national significance be given some positive weighting

Wherever possible, MLA should support people who have an established record [but note recommendations on post-graduate scholarships]

An indication be given that for long term investment projects support will be provided for an agreed time frame greater than the normal period of support subject to satisfactory progress being made and milestones being met

Funding

With the exception of any post-graduate scholarships which MLA might fund, we envisage that all its other investments will be joint ventures of one sort or another. We believe that all these opportunities have a public good component and that governments should contribute to their funding. We have already argued the case for RDCs to have a supporting, rather than the main, role in funding public sector pasture plant breeding [p 50]. We strongly reiterate the view that providing the basic staff and associated infrastructure required for such improvement programs requires public investment, with RDCs investing in

specific projects, not providing long-term funding for core activities. Whilst it might be more difficult to assign the responsibilities of MLA and public sector bodies in other joint R&D projects, we cannot envisage many circumstances where MLA should be expected to contribute the majority of the funding needed. Discussions with government bodies on relative investment levels will be necessary, and we envisage that MLA might use its proposed investment as leverage in the negotiations.

It is axiomatic that MLA"s interests may overlap with those of other RDCs. The recent decision of AWI, GRDC and LWA to join with MLA in undertaking a scoping study to investigate the establishment of a Sustainable Grain and Grazing Systems Program illustrates this principle. The convergence and overlap of interests provides an opportunity to develop collaborative programs and/or define responsibilities for specific RDCs, thus making more efficient use of the resources available. Biotechnology provides a good example. We believe it is in the interests of MLA, and other RDCs, for that matter, to share the funding of an agreed program, which will inevitably be expensive. Other related topics where we recommend close collaboration between RDCs include exploring the possibility of standard procedures for the management of IP, including issues of commercialisation.

Continuing collaboration requires continuing contact. We would favour regular meetings of a representative of a number of RDCs which could [i] determine and assign specific R, D & E topics to one or more Corporations, [ii] agree on levels of cooperation and funding, and [iii] discuss any other matters of interest to more than one participant body. The members of this group might be AWI, DRDC, GRDC, LWA, MLA and, perhaps RIRDC. We are loathe to recommend the establishment of another committee. Instead, we suggest that representatives of the above RDCs could get together after meetings of the national committee reporting to PIC. Alternatively, a representative of DRDC might be added to the SGGS group when R & D responsibilities of the RDCs are being discussed.

We would also favour pragmatic arrangements being made to ensure close working relations between bodies investing in a program. For example, if MLA decided to invest in the selection of perennial plants for dryland salinity [Opportunity 1] and/or the development of management packages for new legumes [part of Opportunity 6a], and the work became part of NAPLIP, we believe MLA should be a member of that program.

Joint ventures in the development of improved cultivars, in which MLA has been, or still is, involved, together with a research provider [usually a government body] and a commercial partner, have gained widespread acceptance and approval. We envisage that there will be more opportunities for MLA to invest in similar joint ventures, and we believe that the Company take advantage of any such opportunities. In fact, we would go further and recommend investment in any opportunities, whether in Australia or overseas, which MLA is satisfied will provide a significant potential benefit to red meat producers.

The other avenue that the Company has to develop joint ventures - through the MLA Donor Company Limited [see Appendix 7] - appears a valuable option for attracting commercial investment in innovation. This Company, which we understand caters for projects involving some IP such as a patented or protected gene or a novel endophtye, fills a niche distinct from that catered for by the normal funding arrangements. The range of services supplied by MLA to partners seems to have been welcomed by the private sector, particularly by entrepreneurial companies. In spite of the apparent limited knowledge of its existence, some 35 projects with a total budget in excess of $16 m had been approved by December 2001, less than three years after the company was established. Some seed company executives have lost no time in seeking further information about the company and two plant breeding projects are under consideration for support. The company could have a positive effect on levels of investment in R & D and flow-on benefits to the red meat industry.

We understand that the Donor Company is currently moving towards a more proactive approach to involving the private sector and pursuing MLA strategic directions with such promotion. As pasture plant breeding, including biotechnology, is now dependent in part on private sector funding, promotion by the Donor Company of pasture plant breeding projects could well be regarded as a strategic positioning by MLA. We suggest that MLA adopt such a strategic position and promote this area through the Donor Company [see Recommendation on p 31].

Project monitoring

Milestone and project reports, together with independent reviews of large projects are processes widely used by RDCs to monitor the progress of investigations. We see no reason to recommend any change to this practice. However, in our review of previous MLA investments in pasture plant improvement, we had some concerns on the form of both milestone and final reports, which were often inconsistent in the amount and quality of the information included. We also felt that summaries of completed projects, consolidated in an easily accessible data base, should be an integral part of implementing MLA"s future research strategy. A number of recommendations have already been made to improve the reporting and monitoring of the projects, and make better use of the outcomes of the work [see pages 18-19].

Outcomes

Little provision is presently made to ensure that projects provide good information on outcomes that are often impossible to quantify at the completion of the investigation. We think it is important to remedy this shortcoming, especially as expected outcomes and industry impacts should provide the rationale for project investment. Further, we believe that information on project outcomes and industry impacts should be used by MLA to publicise its contribution to pasture improvement and increase its visibility within the industry. It is particularly important to target farmers/graziers, extension workers and consultants, many of whom appear unaware of MLA investments in key pasture management programs. The information will also assist the required reporting of MLA"s activities to AFFA [Agriculture, Fisheries and Forestry-Australia].

We believe that dissemination of outcomes and industry impacts could be improved by a planned and continuing operation. It could include greater targeted use of the media, particularly the print media, wider use of the Company"s regional committee members, increased presence at rural events such as agricultural shows, presentations at farm field days and workshops and the development of an email delivery system.

Recommendations

Total funds available for investment in pasture improvement be divided in proportions of some 35% for projects covering the selection and breeding of improved pasture plants and 65% for projects on other key activities in pasture improvement. We also propose that a maximum of 40% of funds available for pasture plant improvement be allocated to biotechnology a committee [with representatives of government, RDCs and agribusiness] be established to determine national priorities for R, D and E and assign broad responsibilities to participating groups to undertake and fund the necessary investigations an advisory committee should be set up by MLA to assist in determining specific projects for investment and advising on research providers.

Summary

Our response to Objective 4 can be summarised thus : -

° A précis of our perception of the role of MLA is followed by some explanation of the criteria used selecting a number of opportunities recommended for MLA investment in pasture improvement. These include projects in extension, plant selection for difficult environments, cultivar improvement, sustainability, weed control, modelling and funding of post-graduate scholarships

° Proposals are included for continuing investment in plant improvement within a broad portfolio of projects which we are confident will provide major benefits for the red meat industries in short and longer term

° Extension activities and problems associated with salinity stand out as the highest opportunities for new MLA investment

° Suggestions are made for a split in funding between plant improvement and other activities in pasture improvement, and between conventional breeding and biotechnology

° A section on the possible role of MLA in different scenarios is followed by some proposals we believe are needed to properly develop and implement an investment strategy for MLA. They include recommendations to obtain a national perspective for R, D and E in pasture improvement and for continuing input from producers. Guidelines are included for choosing projects in which to invest and suggestions made for obtaining advice in selecting such projects. Some discussion is included on joint funding of projects in the public and private sectors is included, and the importance of more uniform project monitoring and evaluation and the value of wider dissemination of project outcomes and impacts stressed.

Acknowledgements

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5. Critique of MLA model

6. Some International Seed Companies

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APPENDIX 1

REVIEW TERMS of REFERENCE

MEAT & LIVESTOCK
AUSTRALIA

Terms of Reference

Review of Pasture Evaluation and Improvement Investment
for the Lamb and Sheepmeat Industry

Project Definition/Background:

Definition of Pasture Evaluation and Improvement

Pasture improvement is defined broadly as all research, development, and onfarm activities relating to production of pasture. Within pasture improvement are the specific activities relating to pasture breeding, selection and evaluation, which is the focus of Stage 1 of this project.

MLA previous investments

MLA and previously Meat Research Corporation have invested over the last 15 years in a range of R&D activities in pasture breeding, evaluation and management. To date there have been subclovers, lucernes, tall fescue, white clover, phalaris, microlaena, perennial ryegrass, annual ryegrass, and LIGULE native grasses released. Work continues on bloat resistant white clovers and lucernes and native and low input grasses. The major investment in pasture management has been through Sustainable Grazing Systems Key Program.

Changing commercial environment

Since these investments were made plant breeders rights legislation has impacted on the increasing role that private seed companies have in breeding and evaluation of pasture species. During this period a number of national pasture breeding programs were formed to coordinate and facilitate the public sector programs. As a result MLA has reduced funding in cultivar development and focused on investments that support basic science areas that underpin the future development of pasture species.

At the same time the seed companies operating in Australia are now part of multinational life sciences companies with global outlooks. Generally the public sector pasture breeding agencies have struggled with reduced government funding.

Any review will need to consider the objectives of these companies, public sector input and the synergies that can be created with MLA to achieve mutual objectives.

Increasing role of biotechnology in pasture improvement

A review was undertaken by MLA and Australian Wool Innovation Ltd that sets out the role that biotechnology may have in complementing conventional breeding. An draft report has been produced.

Greatest returns for lamb and sheepmeat businesses

Over this period MLA investment in the feedbase area has focused on areas that can have a greater impact on the profitability of grazing businesses. In terms of lamb and sheepmeat businesses improved efficiency of production is the area of greatest potential return for most producers, but in a scale of activities an individual producer can undertake to improve the production efficiency, resowing of pastures generally falls behind other management interventions, such as grazing management.

The question we are asking is what are the needs, opportunities and potential impact from investment in pasture improvement and what are the likely benefits?

MLA role

Also we need to consider what role should MLA have in pasture evaluation and improvement area?

MLA contracts R&D against industry strategic plans to meet industry goals. In the current Lamb and Sheepmeat Research & Development Plan pasture breeding per se did not rate as an industry objective, but contributes directly to the following two objectives;

2.2 Increase the proportion of the land area used from pastures incorporating a perennial phase

I. A. Increase the proportion of production that is from production systems that are environmentally sustainable particularly in relation to deep drainage of waters, movement of soil nutrients from soil profile and loss of biodiversity

And pasture strategies can impact on these objectives;

I. A. reduce the cost of production per kilogram of lamb produced by 4% per annum

1.4 increase average lamb carcase weight by 2.5% per annum

1.9 increase average mutton carcase weight by 1.5% per annum

MLA has the capacity to provide matching R&D funds to commercial companies against specific project proposals. This mechanism is known as the MLA Donor Company. Some seed companies have already received funding through this mechanism to pursue pasture improvement and breeding activities.

Scope of the review

The scope of this review is the feedbase for lamb and sheepmeat businesses in the high rainfall and wheat-sheep zones.

The reviewers will be expected to liaise with key industry and research personnel and organisations and draw on related literature. MLA will make project files available in confidence.

MLA has developed an onfarm R&D evaluation model, which may be made available for this review.

Project Objectives

Stage 1

1. Review previous MLA and MRC investments and identify the impact for sheepmeat and lamb producers.
2. Identify opportunities for pasture improvement considering the individual lamb and sheepmeat businesses needs, community and industry needs and the technologies that are now available.

a. It is expected that the current rates of genetic gain for production and disease resistance traits in pasture plants by conventional breeding and biotech processes will be identified.

b. It is also expected that the potential for biotech to improve the rate of genetic gain is identified.

Stage 2

1. Identify the likely cost of these investments and the likely impact for sheepmeat and lamb businesses, industry and community.
2. Identify the current capacity in Australia and overseas to undertake pasture improvement work.
3. Suggest an investment strategy for MLA taking into account the various mechanisms by which MLA can fund this work and the MLA role.

Reporting and Liaison

The Consultant will report to MLA through Gabrielle Kay or Cameron Allan.

The Consultant will be required to;

1. Meet with MLA and revise the methodology for Stage 1
2. brief emails updating progress and identifying issues each week
3. draft final report presented and discussed with MLA
4. final report for Stage 1

Key Milestones

Milestone	Date
1. Proposals received	17 December 2001
2. Consultants notified, work plan Stage 1 negotiated and contracted	1 March 2002
3. Draft final report for Stage 1 received and presented to MLA	30 April 2002
4. Determine progression to Stage 2	30 April 2002
5. Final report completed for Stage 1	15 May 2002

APPENDIX 2

ANNUAL MLA INVESTMENTS [1998/99 - 2001/02]

ANNUAL MLA INVESTMENT IN PASTURE PLANT IMPROVEMENT PROJECTS

Project Number investment	Actual /Committed $	Years	Level $	Total $
DAV 094	Actual	1993-1994	155,000	
Perennial ryegrass		1994-1995	149,976	
improvement		1995-1996	150,000	
		1996-1997	147,000	
		1997-1998	157,986	759,962
DAV 095	Actual	1993-1994	51,745	
Tall fescue		1994-1995	53,520	
improvement		1995-1996	48,745	
		1996-1997	11,563	165,573
TR 028	Actual	1996-1997	30,378	
Tall fescue		1997-1998	33,913	
commercialisation		1998-1999	33,301	97,592
DAS 021	Actual	1989-1990	102,289	
SARDI lucerne		1990-1991	124,860	
improvement		1991-1992	136,212	
Stage 1		1992-1993	5,862	369,223
DAS 030	Actual	1992-1993	195,414	
SARDI lucerne		1993-1994	200,422	
improvement		1994-1995	182,481	
Stage 2		1995-1996	183,965	
		1996-1997	144,800	907,082 [plus royalties]
	TR 041	Committed	1997-1998	10,000
White clover		1998-1999	40,000	
improvement for		1999-2000	40,000	
dryland environments		2000-2001	20,000	
		2001-2002	10,000	120,000
CS 210	Actual	1993-1994	77,136	
Phalaris screening for		1994-1995	71,823	
toxic substances		1995-1996	70,997	
		1996-1997	54,837	
		1997-1998	18,279	293,072

Project Number	Actual/Committed	Years	Level $	Total $
UNE 039	Actual	1993-1994	83,533	
Microlaena stipoides		1994-1995	102,502	
Agronomy and		1995-1996	90,065	
Commercialisation		1996-1997	92,130	
		1997-1998	84,233	
		1998-1999	10,000	462,463
M 551	Actual	1994-1995	53,694	
LIGULE		1995-1996	53,694	
		1996-1997	53,694	
		1997-1998	57,400	218,482
TR 045	Committed	1997-1998	30,000	
Native and Low Input		1998-1999	30,000	
Grass Network		1999-2000	20,000	
	`	2000-2001	10,000	90,000
CS 114	Actual	1990-1991	174,638	
Biotechnology Bloat		1991-1992	75,000	
Project [Stage 1]		1992-1993	24,740	274,378
CS 184	Actual	1992-1993	218,703	
Biotechnology Bloat		1993-1994	228,026	
Project [Stage 2]		1994-1995	244,995	
		1995-1996	321,180	1,012,904
CS 184b	Actual		2,858•	
Biotechnology Coordinator				
TR 014	Actual	1996-1997	251,936	
Biotechnology Bloat		1997-1998	190,302	
Project [Stage 3]		1998-1999	272,907	715,145
AGRES 001	Actual	1994-1995	28,750	
Tall fescue		1995-1996	63,900	
Technology Adoption		1996-1997	90,140	
		1997-1998	133,400	
		1988-1999	87,200	403,390

• not included in annual totals

Project Number	Actual/Committed $	Years	Level $	Total $
DAN 082	Actual	1994-1995	90,433	
Lotus Grazing		1995-1996	64,966	
Management		1996-1997	81,536	
		1997-1998	98,308	335,243
DAN 070	Actual	1992-1993	35,000	
Chicory		1993-1994	27,666	
Filling feed gap		1994-1995	27,666	
		1995-1996	18,000	
		1996-1997	3,667	
		1997-1998	6,000	117,999
PICU 106	Actual	1999-2000	34,670	34,670
ARGT Toxicity Investigation				
CS 278A	Actual	1996-1997	10,850	10,850
Lucerne Global Market				
[DAW 001S	Actual	up to 1987	385,167	
Evaluation of annual		1987-1988	47,965	
pasture legumes in WA		1988-1989	58,913	492,045]

Annual investment from 1989 -1990

Year	$
1989-1990	102,289
1990-1991	299,489
1991-1992	211,212
1992-1993	479,719
1993-1994	823,528
1994-1995	1,005,840
1995-1996	1,065,512
1996-1997	972,531
1997-1998	819,811
1998-1999	473,408
1999-2000	94,670
2000-2001	30,000
2001-2002	10,000
TOTAL	6,388,009

APPENDIX 2A

LIST OF ADDITIONAL PROJECTS - NOT INCLUDED IN REVIEW

List of additional projects supplied by MLA

Project number	*Project title*
DAS.010	The agronomic management and nutritional evaluation of grain legume crops
DAS.021	Development of new dryland grasses for the grazing industries
DAS.024	Breeding ARGT resistant ryegrass
DAS.033	Identification and utilisation of superior grasses
DAS.035	Developing an early flowering AGRT resistant ryegrass
DAW.001a	Evaluation of sown annual legumes
DAW.023s	Annual medic for Kalgoorlie
DAW.046	Perennial pastures for animal production
DAV.064	Tagasaste
DAN.009s	Legume innoculants
DAN.090	Grazing strategies 400-600 mm
M.707	AGIP Coordinator
DAV.094a	Review of DAV.094
M.402	Coordinator AGIP
M.302	Extension strategy for Guard - an ARGT resistant ryegrass

APPENDIX 3

QUESTIONNAIRES

MLA Review on Investment in Pasture Improvement

Meat and Livestock Australia Ltd [MLA] has decided : -

[i] to seek a review of its past investments in pasture improvement for the red meat industries [lamb, sheepmeat and beef producers] - particularly projects covering the selection, breeding and evaluation of improved pasture plants, and

[ii] as part of the process, to identify opportunities for further pasture improvement, to meet the needs not only of the red meat producers, but also and those of the wider community and industry. In considering such opportunities, MLA expects that the review will identify „current rates of genetic gain for production and disease resistance traits in pasture plants by conventional breeding and biotech processes" and „the potential for biotechnology to improve the rate of genetic gain".

The Corporation has also asked for information on the relative rates of pasture improvement, animal output and net farm income which have arisen from the release of improved varieties compared with those from management practices e.g. renovation, fertiliser application or grazing regime. Although the major objective of the present exercise is to meet the needs of the red meat industry, many of the principles of such pasture improvement can be expected to be valid for both other pastoral industries and wider community interests.

An important part of the review [to be undertaken by Alec Lazenby, Ted Wolfe and Peter Chudleigh] will therefore be to seek the opinions, supported by any relevant data which may be available, of a range of interested parties on the outcomes of R & D on pasture improvement. These include graziers and farmers, administrators, researchers, extension workers, consultants, R & D Corporations and the private sector, including the seed industry. It follows that we would like to hear their opinions on the value of work previously funded not only by MRC/MLA but by other R & D Corporations, the public sector and the private sector.

It is also important that interested parties articulate their ideas on opportunities for future pasture improvement. It would be helpful if they were able to indicate [i] what they believe to be the relative importance for such pasture improvement of releasing improved cultivars compared with other factors such as reseeding, fertiliser regime or grazing management and, [ii] any problems envisaged in achieving desirable outcomes and/or implementing them.

We have taken the liberty of preparing questionnaires for different groups [the relevant questionnaire[s]are enclosed], giving advanced notice of the main topics on which members of the review team would particularly like to hear your views. Unless requested otherwise, it would be our intention to keep the interviews anonymous. We will also respect any information provided in confidence.

Thank you for your help.
Alec Lazenby, Ted Wolfe and Peter Chudleigh

Questionnaire for Graziers/Farmers, Administrators, Extension workers and Consultants

In responding to the questionnaire, it would be most helpful if you could indicate the context in which your comments are made, e.g. national, state, region or particular production system.

1. What are the biggest impacts that pasture improvement has had in the past 10 years? What type of R & D had contributed to these impacts?

2. List any pasture projects supported by MLA/MRC of which you are aware and indicate what effects these projects have had, e.g. increasing awareness, changing industry practices, boost of productivity.

3. Which aspects of pasture plant improvement [selection, breeding and evaluation of varieties] have been of most benefit to on-farm practice, particularly [but not exclusively] to the redmeat (lamb, sheepmeat and beef) producers?

4. How has any such benefit been expressed, e.g. better establishment, increased persistence, improved control of undesirable species, higher stocking rates throughout the year or in a particular season, enhanced pasture quality, higher reproductive rates, better quality and/or more animal production, or increased net farm income?

5. How do any improvements in the performance of pasture plants relate to, or compare with, improvements resulting from better pasture management, e.g. fertilizer regime, renovation, grazing intensity or management system?

6. Do you have any information or data to quantify the gains resulting from

   [i] plant improvement and [ii] pasture management on pasture performance, animal production or net farm income?

7. What (i) gains have followed the replacement of native species with introduced plants, e.g. in total or seasonal pasture growth, animal output, or net farm income, (ii) problems have you encountered as the result of using such introduced plants, e.g. increased pasture susceptibility to water stress, high temperatures or grazing pressure?

8. What are your thoughts on the contribution of pasture plants to the improvement or degradation of the soil, water and vegetation resources of catchments? Are there any differences between the effects of native and introduced species? What do you think needs to be done to restore the soil, water and vegetation resources?

9. Which aspects of future pasture improvement do you think provides the greatest opportunities for potential gains in the performance of plants in pastures, animal output, and economic and ecological sustainability? Indicate any difficulties you perceive in achieving these objectives. Indicate your ranking by inserting 1 (small impact), 2 (medium impact) and 3 (impact) in the following table: -

	Potential gain in

Aspect of pasture improvement	Plant performance	Animal performance	Net income	Sustain-ability	Other
Traditional plant breeding					
Biotechnology					
Establishment					
Fertilising					
Renovation					
Grazing management					
Extension					
Other					

10. What is your expectation of the potential decline in pasture performance if specific problems are not highlighted and addressed through conventional breeding and biotechnology?

11. What balance of R & D funding do you recommend for the domestication of native species and the improvement/adaptation of introduced plants? Do you have an opinion on the relative level of investment in [i] a targeted and well - managed program of breeding and evaluating an important pasture species, and [ii] a high risk project or program which could provide a good return, if successful?

12. Which organisations and bodies do you feel should be involved in funding pasture improvement projects? Indicate the role, if any, you think should be played by the public sector [state governments, CSIRO and universities], R & D Corporations, producers [directly] and the private sector in supporting plant improvement projects or programs. How should any such responsibilities be funded - solely by one sector, through collaborative funding involving e.g. a number of R & D Corporations or Co-operative Research Centres, or joint ventures between different public and private sector bodies? Examples of the type of project and its method of funding would be most helpful.

13. Any other topics which you feel might be discussed within the framework of the review.

Questionnaire for Plant Breeders and Research Agronomists

1. Which areas of pasture plant improvement [selection, breeding and evaluation of varieties] have been of most benefit to grassland output? Do such improvements apply equally to the red meat industries (lamb, sheepmeat and beef) and to the other pastoral enterprises of wool and dairy production? If not, indicate any differences.

2. How has any such benefit been expressed, e.g. in availability of seed, ease of establishment, increased dry matter production, better seasonal distribution of herbage, enhanced pasture quality, pest or disease resistance, ease of management or increased animal output?

3. How do any improvements in the performance of pasture plants relate to, or compare with, improvements resulting from better pasture management, e.g. fertilizer regime, reseeding, grazing intensity or management system?

4. What data, if any, are available to quantify the absolute and relative effects of plant improvement and management in increasing pasture output?

5. What problems, if any, have you experienced following the use of introduced species and improved cultivars, e.g. increased susceptibility of the pasture to adverse growing conditions or environmental degradation? Describe the conditions under which any adverse effects have been encountered.

6. Which aspects of pasture improvement e.g. better establishment, persistence, tolerance of a limiting factor, resistance to pests and diseases, removal of an anti-nutritional factor; weed control, soil acidity and catchment hydrology, do you think provides the greatest opportunities for potential gains in (i) herbage performance and/or animal output, and (ii) economic and environmental stability? Indicate any perceived difficulties in achieving these objectives.

7. What role do you think biotechnology [gene marking, gene mapping and introduction of new genes] could play in future pasture plant improvements? How should biotechnology relate to conventional breeding, indicating the value and limitations of the two methodologies in selecting better plants. Do you have any information on the actual or potential genetic gain in plant characters or animal output of conventional breeding and biotechnology?

8. What relative balance of R & D funding do you think should be allocated to the domestication of native species and the improvement/adaptation of introduced plants?

9. Indicate any deficiencies in the present funding of pasture plant improvement. How do you think that any such deficiencies might be realistically addressed e.g. by an increased level of funding from the public sector, by R & D Corporations taking more responsibility for supporting plant improvement, or joint ventures involving, say, R & D Corporations and the public or private sectors?

10. Which organisations and bodies do you feel should be involved in funding pasture improvement projects? Indicate the role, if any, you think should be played by the public sector [state governments, CSIRO and universities], R & D Corporations, producers [directly] and the private sector in supporting plant

improvement projects or programs. How should any such responsibilities be funded - solely by one sector, through collaborative funding involving e.g. a number of R & D Corporations or Co-operative Research Centres, or joint ventures between different public and private sector bodies? Examples of the type of project and its method of funding would be most helpful.

11. What factors should be incorporated in a realistic system to evaluate improved cultivars? What were the values and limitations of the APPEC system of testing?

12. Any other topics relevant to the review which you would like to discuss

Questionnaire for biotechnologists

1. What current research are you aware of that is applying biotechnology to the improvement of pasture plants, e.g. to achieve gains in one or more attributes of : seed production, ease of establishment, persistence, tolerance of a limiting factor, tolerance/resistance to pests and diseases, removal of an anti-nutritional factor; yield advantage, weed control; the productivity/quality of animals; and/or benefits in dealing with environmental issues such as weed control, soil acidity and catchment hydrology? Indicate the main focus of the work [gene transfer, development of molecular markers, market assisted selection] At what stage is the work, and how long might it be before the commercial release of an approved cultivar based on the application of biotechnology?

2. What is your estimate of the potential rates of genetic gain in plant traits such as disease resistance, improved quality or herbage production from the use of biotechnology? How do these compare quantitatively with the rates of improvement achieved or achievable through conventional plant breeding?

3. What role do you envisage for biotechnology in future pasture plant improvement? How should biotechnology inter-relate with conventional breeding? Indicate any advantages and difficulties associated with the two methods of plant improvement

4. Do you think that future R & D funding on pasture plant improvement should be directed (i) entirely to biotechnology, or (ii) split between biotechnology and conventional plant breeding? If the latter, what relative proportions should be allocated to the two activities?

5. Do you feel that the present funding arrangements for biotechnology are satisfactory? Indicate any realistic improvements which might be considered, e.g. a guaranteed level of project or program funding for a period of, say, at least five years

6. What is the relationship, if any, between the period when some large benefit may occur and the level and length of investment? For example, assuming no constraints on capacity, if a $1m per annum investment in biotechnology took 10 years to produce a bloat-free lucerne, how long would it take if the project was supported at the level of $3m per year? How would the chances of success be affected by such increased rate of funding?

7. Which organisations and bodies do you feel should be involved in funding pasture improvement projects generally, and biotechnology in particular.? Indicate the role, if any, you think should be played by the public sector [state governments, CSIRO and universities], R & D Corporations, producers [directly] and the private sector in supporting

conventional breeding and biotechnology. How should the work be funded - solely by one sector, through collaborative funding involving e.g. a number of R & D Corporations or Co-operative Research Centres, or joint ventures between different public and private sector bodies? Examples of the type of project and its method of funding would be most helpful.

8. Could you comment on the possibility of negative effects arising from the introduction of novel genes? For example, what is your estimate of the ecological risk, of e.g. overuse of a particular herbicide, depletion of the soil P pool, development of subsoil acidity, that might accompany the introduction of particular genes, for herbicide resistance, unlocking phosphate and aluminium- tolerance, into a pasture species?

9. What views do you have on the effects of IP in constraining the implementation of successful technologies?

10. Comment on the consequences of Australia failing to invest adequately in the new technologies from the perspective of the feedbase of the lamb, sheepmeat and beef industries and the accessibility of these industries to improved pasture plants.

11. Any other topics relevant to the review that you would like to discuss

Questionnaire for seed companies

The review team would appreciate information and your views on : -

(i) the seed market and the seed industry in Australia and overseas

(ii) the main pasture cultivars commercialised by your company and the markets supplied within Australia and/or overseas

(iii) any foreseeable changes to the plant types to be commercialised or to the markets to be targeted. Do you have a strategy to achieve any expanded role?

(iv) the importance to the company of improved pasture cultivars bred in Australia which are marketed currently. [Any information on cultivars bred in the public sector where the work was supported by MLA or MRC will be particularly valuable]

(v) factors limiting further improvement of pasture cultivars, e.g. seasonal or total DM production, quality, seed production, resistance to pests and diseases, tolerance to heat, drought or acid soils, toxicity, improved method of evaluation, and the feasibility of making the improvements

(vi) market needs and industry outcomes. Are they ever in conflict? If, so, how might any such conflict be managed?

(vii) new technology, including a consideration of its value and limitations in improving pasture plants. Views on the roles of, and inter-relationship between, conventional breeding and the new technology in achieving improvements would be especially welcome.

(viii) plans and strategies, and the capacity , of the company to take advantage of the new technology

(ix) the future of pasture plant breeding e.g. should the public sector have an increased, diminished or a continuation of its present role in breeding [as distinct from evaluating and commercialising] pasture plant cultivars? Indicate any differences between your own ideas and company policy.

(x) Which organisations and bodies do you feel should be involved in funding pasture improvement projects? Indicate the role, if any, you think should be played by the public sector [state governments, CSIRO and universities], R & D Corporations, producers [directly] and the private sector in supporting plant improvement projects or programs. How should any such responsibilities be funded - solely by one sector, through collaborative funding involving e.g. a number of R & D Corporations or Co-operative Research Centres, or joint ventures between different public and private sector bodies? Examples of the type of project and its method of funding would be most helpful.

(xi) at what stage in plant improvement would you prefer to obtain the material from the public sector e.g. unselected plants newly collected from Australian or overseas sources; genetically modified but unselected gene pool; enhanced genetic material; newly bred cultivar?

(xii) Intellectual Property and its effects on pricing policy and adoption rates

(xiii) how might R & D Corporations generally, and MLA, in particular, assist in funding cultivar improvement? Should this support be focused on [a] specific projects in the public sector [b] joint ventures involving the public and private sectors, [c] providing matching funds to support specific company projects? If you consider that MLA funding should be made available for more than one category, nominate the topics that you think should be supported

(xiv) the MLA Donor Company and possible joint ventures with private companies to support R & D projects in the private sector

(xv) the importance of cultivar evaluation? What were the values and limitations of the APPEC system of testing?

(xvi) any other matters, relating to the selection, breeding, evaluation or commercialisation of improved pasture plants, on which you wish to comment.

Questionnaire for R & D Corporations

1. What strategy has the Corporation followed when investing in pasture plant improvement - specifically in the selection, breeding and evaluation of pasture plants? Specify any projects or programs in which significant investments have been made by the Corporation.

2. What process[es] does the Corporation use to monitor and/or evaluate such work, e.g. [i] by progress and final reports on the projects, [ii] internal/external reviews, [iii] identification and quantification of improvements in plant traits, superior pasture performance, animal output, environmental effects such as soil acidity, weed control, catchment hydrology or sustainability characteristics, or [iv] an estimate of the actual and/or potential impact on the industry?

3. What is your present philosophy and practice on the support of plant breeding and evaluation? Do you envisage any foreseeable changes in the type of program or project your Corporation is likely to support?

4. How do you rate the relative potential for pasture improvement through investment in the breeding and adoption of new cultivars compared with investment in factors such as reseeding, fertilizer regime or grazing management? Do you have any relevant data to quantify such relative effects? If not, please give reasons for your opinion[s].

5. Which aspects of future pasture improvement do you think provides the greatest opportunities for potential gains in herbage performance, animal output, and economic and ecological sustainability? Indicate any difficulties you perceive in achieving these objectives. Where do you feel that R & D dollars are best invested?

6. Which organisations and bodies do you feel should be involved in funding pasture improvement projects? Indicate the role, if any, you think should be played by the public sector [state governments, CSIRO and universities], R & D Corporations, producers [directly] and the private sector in supporting plant improvement projects or programs. How should any such responsibilities be funded - solely by one sector, through collaborative funding involving e.g. a number of R & D Corporations or Co-operative Research Centres, or joint ventures between different public and private sector bodies? Examples of the type of project and its method of funding would be most helpful.

7. Do you believe that the private sector can function without industry support for pasture plant improvement? Indicate the reasons for your conclusion.

8. What effect on long term pasture productivity do you think would follow if specific limitations to pasture plant performance were not addressed through conventional breeding and biotechnology? Has the Corporation given any thought to the relative level of investment in [i] a targeted and well-managed program of breeding and evaluating an important pasture species, and [ii] a high risk project or program which could provide a good return, if successful?

9. What policy does your Corporation have for funding new technology, including both genetic engineering and gene marking and mapping, in the context of pasture plant improvement? What attitude does it take to the debate on GMOs?

10. In what activities, if any, is your Corporation involved in the commercialisation of pasture improvement? What do you feel about the commercialisation of R & D? Indicate any concerns of such commercialisation in meeting industry needs

11. What practice is adopted for managing intellectual property. Do the potential constraints arising from IP and GMO influence the allocation of your R & D funding?

12. Comment on the value and limitations of the APPEC system of evaluating improved pasture plant cultivars. What attributes should be included in any future system of variety evaluation?

13. Any other issues relevant to the review which you would like to discuss

APPENDIX 4

LIST OF SURVEY PARTICIPANTS

Contributors to the review
(people interviewed and those making written responses)

Mr Cameron Allan, Administrator, MLA Orange NSW
Mr Malcolm Anderson, Research Scientist, PVI, Hamilton VIC
Dr Ken Archer, Program Manager, Pastures and Rangelands, NSW Ag, Orange NSW
Mr Geoff Auricht, Pasture Leader, SARDI, SA
Dr John Ayres, Researcher, NSW Agriculture, Glen Innes NSW

Dr Roger Barlow, Feedbase Coordinator, DRDC
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Mr John Coughlan, Farmer, Cudal, NSW
Mr Andrew Craig, Senior Research Scientist, SARDI, SA
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Mr Colin Grant, Manager, Seedco Australia Co-operative Ltd, Hilton SA
Mr Simon Gubbins, Farmer, Hamilton VIC

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Mr John Harvey, Executive Manager, Program Operations, GRDC
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Dr Bill Johnston, Senior Terrestrial Ecologist, NSW Land and Water Conservation, Queanbeyan NSW

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Professor David Kemp, Faculty of Rural Management, University of Sydney, Orange NSW
Mr Terry Kenny, Farmer, Murray Bridge SA
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Mr Phil Price, Program Manager, National Salinity Program, LWA

Dr Kevin Reed, Resources Manager, Plant Science, PVI, Hamilton VIC
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Mr Peter Walch, Farmer, Patchewollock VIC
Mr Peter Ward, Farmer, Loddon Campaspe branch, Grassland Society of Victoria

Mr Hugh Watson, Farmer, Albury Wodonga branch, Grassland Society of Victoria
Associate Professor (Honorary) Wal Whalley, Researcher, UNE, Armidale NSW
Ms Sue and Mr Guy Wheal, Farmers, Limestone Coast branch, Grassland Society of Victoria
Dr Bruce Wicking, Managing Director, Seedco Australia Co-operative Ltd, Hilton SA
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APPENDIX 5

CRITIQUE OF MLA MODEL - VERSION 12.3.1

INTRODUCTION

This critique has been prepared as a result of using the MLA scoring model to assess a number of opportunities for investment in pasture plant improvement. The model did prove useful for this purpose, although there were a number of difficulties encountered.

This document is intended to be a constructive critique to assist MLA further develop the scoring model. The comments refer to both serious and minor issues. Some issues raised obviously need attention. Attention to others would be optional.

GENERAL COMMENTS

Purpose of model

The MLA model is an effective tool in assessing project proposals and other ideas for R&D investment in terms of their potential impact and benefits and their fundability. The first scoring component appears particularly helpful in assembling scores from different personnel in making overall subjective assessments. The second component, the calculation of investment criteria, dominates the input and handles the potential applicability of an assumed impact across different production systems particularly well. It also accounts for the unit impact estimate and the adoption profile quite well. However, the investment analysis routine is somewhat inflexible and can not always be tailored to the diverse nature of many projects and the associated best investment analysis framework.

Hence, we tentatively conclude that the model is useful for screening in a consistent manner a large number of potential projects using a subjective scoring system. It can also provide investment criteria but it is less adequate in this regard than tailor made analyses. Compared with such analyses, it is quicker to use but there is a tradeoff in speed versus accuracy. The model does have the strength of using a common set of data for each appraisal, but this may also be possible in other approaches.

Who is to use the model

Without documentation it is difficult and time consuming to learn initially to use the model. However, MLA program managers and coordinators, when familiar with the model, should find it useful and informative. For the casual external user, such as in the current review of pasture plant improvement opportunities, documentation is highly recommended, if the model is to be cost-effective to use. Even when used in house, it would be easy to misuse the model unless there were precise definitions and a user's manual available.

SPECIFIC COMMENTS

SCORING ROUTINE

1. Graph on project scores summary page

From year 11 onwards, this graph seems to add „other" R&D costs, not just MLA costs. Hence the second part of the line on the graph that refers to costs appears high relative to the first part.

2. NPV and the scoresheet

In the scoresheet, the NPV is divided by the MLA contribution to obtain the NPV/MLA R&D costs. It then states that this ratio is capped at 10.

a. This means that a number of high return projects will be capped at ten and the scoring will fail to differentiate between say a NPV of $200 million and one of $20 million, assuming the MLA costs were $1 million in each case. The absolute value of an NPV should not be diminished in this way. Alternatively, a logarithmic scale may be worth investigating.

b. The score is then amalgamated with other criteria scores, many of which are correlated with the parameters that go into estimating the NPV (eg size of impact). Hence there is a degree of double-counting in the final score that will work in favour of some projects more than others. The criteria that are used to make up the final score should preferably be independent. It would be preferable that the subjective scores excluding the NPV be presented separately to the NPV (and the NPV for each project be expressed in actual $ terms). In a sense, the NPV is another representation of the total score, especially if a risk dilution factor was incorporated.

3. Score weights

It would be preferable if there were some explanation of how the weights given to the various raw scores were developed. It would be useful if somehow they could be linked to the strategic plan or goals of MLA or the sheep and beef programs.

4. Definition of research types

It may be useful to adopt specific definitions of R&D investment, for example

- basic research
- strategic research
- applied research
- extension

These definitions may be aligned to MLA strategies or ABS definitions to allow consistent reporting processes elsewhere. At present it appears that basic research encompasses a mix of true "basic" research (perhaps strategic?) and other capacity building investments that don't fit elsewhere, but are more akin to 'strategic' research.

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5. Fixed labour benefits score

What makes the labour benefits score change? We have had difficulty in making it change away from 4. The formula appears to refer to blank cells.

6. To Portfolio Sheet

The R&D costs that are inputted to the portfolio assessment do not match the input data for R&D costs. We suspect numbers transferred may only be linked to sheep R&D costs, not beef? Also the sheet name of NPV_calc referred to in the formula does not seem to appear anywhere else.

7. Decreasing risk

When scoring adoption factors, 'business risk if adopted' ranges from 'no change' to 'very high increase'. There is no allowance for decreasing risk.

DEFINITIONS

8. Sheet 11: Input data for beef.

Net breeder replacement income is $1.50 per DSE. Net breeder replacement income needs to be defined somewhere so that any % change can be understood.

9. Definitions for medium beef, small beef, etc

It would be helpful if there were definitions presented somewhere for these different systems. Some indication is given in Sheet 35 (Adoption Logic for all sheep systems, but system scope is still not clear). Presumably animal numbers and their distribution come from ABS.

10. Owner labour efficiency
We still have some difficulty in understanding this term, how it changes in the model, and how changes should be interpreted. A definition would be useful as it would be for equipment investment above SR efficiency.

11. Aggregation within Terminal Sire Systems
It would be helpful if any subsystems in this system were defined more specifically. For example, the merino ewes producing the first cross ewes (eg Merino x Border Leicester), are they counted in the terminal sire system as well as in the merino medium wool systems? Does the terminal sire system only include first cross ewes mated to prime lamb sires? It would be useful to know the flock distribution between States and within the zones (eg. sheep-wheat and permanent pasture), by State. Another allied question is how often are the subsystems in the model updated?

CALCULATIONS

12. Problem with beef system override of calculated adoption rate
We discovered a problem with the routine in the 'Adoption NPV South' page, relating to beef. This problem also is apparent for northern beef systems. The problem appears when the manual override on the adoption rate is used. The override does not appear to link back everywhere that it should.

One of the inputs to calculating the Net Annual Benefits Stream (row 88) is 'Long Term Benefit/annum' (cell E65). Cell E65 is equal to Cell H47, and this cell is influenced by cells K47 to P47. The numbers in these cells are influenced by K44 to P44. These in turn are calculated from the same adoption scores that calculates the adoption rate which we have overridden. Therefore while the number of businesses adopting can be manually overridden, other factors influenced by the 'calculated adoption rate' such as the long-term benefit per annum are not also overridden with the new manually entered adoption rate. This results in an underestimate of the benefits. A response to this problem with a workaround solution has been received from Rob Rendell and this works satisfactorily.

13. Link between R&D costs in the START routine and those in Sheep R&D costs page
The link between the R&D costs in the START routine and that in the sheep R&D costs does not work satisfactorily. We understand that this has already been recognised and will be remedied. We have entered the $ and % by industry directly into the Sheep R&D costs page as a temporary measure.

14. Sheet 17: Investment criteria calculations
It would be worthwhile checking the NPV calculations as the Excel formulas can differ in their interpretation of end of year/start of year. We repeated one of the calculations using a traditional non-spreadsheet formula method (estimating PVC and PVB and then taking NPV as PVB-PVC). While we achieved the same BCR and IRR as the model, the NPV was different. If we discounted all back to year zero (not year 1) then we achieved the same NPV result as the model. Hence the model produces a NPV that is relevant to year zero. Since the formula in the model is standard when comparing model results, this is not a major issue. But NPVs produced by this model will vary from NPVs from many non-model NPV assessments that use discounting back to year 1.

15. Stocking rate adjustment

Any documentation should include a concise explanation of this adjustment. It appears that this adjustment is not required for beef systems? As we understand the stocking rate routine for say, the sheep systems, stocking rate changes can come about through changes in the flock structure (eg an increase in weaning rate) and then you have to readjust the ewe numbers slightly as you have no more feed and more mouths and body weight to maintain, in order to maintain the original stocking rate. However, stocking rate changes can also come about through deliberate changes in the stocking rate assumptions from the technology being introduced (eg an increase in DM at particular times of the year from a different pasture type).

CATTLE/SHEEP DIFFERENCES

16. Output indicators report.

Cattle are separated into the two production systems but sheep systems are aggregated in the output indicators report. While sheep are broken down into the four production systems within the sheep part of the "Report' Sheet, the output indicators report seems out of balance. Why not aggregate the cattle systems here and just have sheep and cattle reported equally.

17. Differences in sheep and beef routines

We understand that the MLA version of the model including lamb and beef was developed first, followed by the development of the wool systems. This is evident in a few places.

a. For example, in Sheet 12: Adoption and NPV South (Beef), there is only one factor to nominate that encourages adoption, whereas there are 3 factors in the sheep systems. For example, the 'feel good' factor should influence cattle producers as well as sheep producers.

b. When adjusting the stocking rate in the beef routine, changes to other variables such as efficiencies in fuel, labour etc are not automatically calculated as they are in the sheep routines. The user has to manually make all these adjustments which could be a trap for new users. A related problem occurs when there are two impacts such as a stocking rate increase (which improves the efficiency in operating costs), as well as a change in operating costs from other impacts. The sheep routine can accommodate this much more easily than the beef routine due to the lack of links, and subsequent manual entry required for the beef system.

1. Death rate in beef routine
   There is no allowance for changing the death rate in the beef routine, but there is for sheep.

19. Benefit Cost Ratio

The benefit-cost ratio for beef is not presented in the "Cattle summary" or "Report" sheets as it is for sheep

APPLICATIONS

20. Changing base DSE/Ha

At one stage we wanted to test an improvement for those properties that had areas of land suitable for low input perennial native grasses that could be bred. On these areas the existing stocking rate was considered to be about 2 DSE per ha and the improvement would have taken the stocking rate to 4 DSE per ha. Currently the stocking rate for the sheep systems is fixed in the model (eg for a particular system it may be 1.5 DSE per ha per 100mm).

We tried to change the base stocking rate (admittedly a coloured cell) to represent a zone or target market with a very low stocking rate (0.28 DSE/ha/100mm). It appears that a change in the stocking rate is calculated on ewe numbers, which are not linked to this 0.28, and therefore while parts of it such as cost reduction were calculated on 0.28, the stock accounts were still being calculated using a base of 1000 ewes. The resulting impacts appeared far greater than what would be expected.

21. Multiple benefits and target markets

It is difficult to use the model in some instances where there are multiple benefits involved. This occurs when each benefit applies to a different target market. For example, we had the case of a technology to eliminate bloat in cattle grazing lucerne. Benefits were to be represented by a change in the death rate and an increase in lucerne sowing by those suited to lucerne but who currently avoid lucerne due to fear of bloat. These are two different target markets and there does not appear a way to incorporate both benefits in the one analysis.

22. Application to pasture plant improvement purposes

There are two major problems with assessing pasture plant improvement projects with the model. Some projects of this type are likely to take quite long periods to produce outputs ready for adoption (eg. biotechnology projects followed by a traditional breeding program).

a. The period in which the R&D costs can apply (particularly if commercialisation is included) may be greater than 10 years but the model restricts entry to ten years of R&D costs only.
b. Benefits may not occur until say year 17, leaving only three years of benefits as the model is restricted to 20 years from the year of first investment. If the magnitude of the impact is great, the low discount factors operating over these latter periods still do not make benefits after year 20 insignificant. Thirty years could be more realistic to use.

23. Neglect of risk in estimating benefits

There are two aspects here:

a. Where a proposed project is pre-emptive of a situation that could occur, the model is only useful to estimate the benefits (and associated criteria) should that event actually occur (eg the failure of an existing vaccine). Building in the probability of an event occurring, would allow the expected value of the new technology (eg a new vaccine in the situation where there is one already that fails) to be estimated.
b. Different projects have different levels of technical success ratings and hence these can be used in the model through use of probabilities. These probabilities may have the same impacts on benefits and on some costs, when a second round of costs (eg commercialisation) may depend on the technical success of a project. So some care in applying probabilities in some projects would be warranted.

1. Land Degradation

Currently Sheet 36: Degradation is not part of the main routine but could be developed in the future.

A key issue is whether an increase in stocking rate from reduced land degradation or reclaiming production from degraded land is added to any other stocking rate increase determined and inputted earlier? It may be possible to assume a specific stocking rate impact in the data input sheets, adjust the target market to the % of producers/land that could be ameliorated in the appropriate sheep or cattle system, and then treat adoption in the normal way. I can foresee two potential difficulties with this approach:

a. the stocking rate increase would really represent the avoidance of a stocking rate decrease and the cost changes may not be linear or symmetrical up or down (particularly regarding capital)
b. if a technology was being tested that had a stocking rate impact on good land as well as an increased impact on land that was degrading, it might get tricky making assumptions for, and then integrating impacts from the respective target markets for each situation.

We have not developed any special routines along these lines and have assumed that appropriate technologies that will save stocking rate decreases will have similar impacts to those we have calculated, based on stocking rate increases from what currently exists in the model. This approach may be flawed, however.

The NLWRA Theme 6 produced estimates of the value of yield gaps to each of the beef and sheep industries for sodicity, salinity and acidity. The final theme 6 report has just emerged and there may be useful information that can be aggregated into the model from this report.

APPENDIX 6

INTERNATIONAL SEED COMPANIES

SOME MULTINATIONAL SEED COMPANIES

Netherlands	USA
Barenburg	ABI
Cebeco Seeds	Advanta
Joordens	Cal-West Seeds
Mommerstegg	Forage Genetics [owned by Land of Lakes]
Zeller	Pioneer HiBred [owned by Dupont]
New Zealand	**Belgium**
AgriCom	Aventis
Pine Gould Guiness	
Wrightson Seeds	
Denmark	**France**
DFL	RAGT
Germany	**Sweden**
KWS	Svalof Weibull
UK	
Syngenta	

APPENDIX 7

MLA DONOR COMPANY

MLA Research and Development Partnerships [MLA Donor Company Limited]

Overview

MLA"s fully owned subsidiary, MLA Donor Company Limited, provides a vehicle for attracting commercial investment for innovation from individual enterprises. Since the R&D Partnership Program began in March 1999, 35 projects have been approved with a total budget in excess of $16M. The Program has continued to evolve with the following specific objectives : -

- to significantly increase the level of enterprise investment in innovation in the Australian red meat industry;
- to enhance the outcomes of commercially focused innovation thereby ensuring quantifiable commercial returns to individual enterprises and ultimately to the industry overall; and
- to increase the number of successful commercialisations thereby adding to the quantum of innovations available to the industry.

MLA provides a range of services to partners within the R&D Partnerships Program including:

- funding - utilising available matching Commonwealth funds;
- project development;
- project management and technical services;
- commercialisation and business services; and
- industry benefit diffusion.

It is anticipated that the number of partnerships will continue to grow in 2001/02 to take advantage of the available Commonwealth funds (as set by the 0.5% G.V.P. ceiling).

Progress Report

The R&D Partnerships Program currently has 50 projects underway, with external partners from all sectors of the red meat industry. In addition, eight projects have been completed and commercialisation/dissemination strategies are underway to ensure industry benefit is achieved. The Program was relaunched at the commencement of 2001-2002 with a new information kit and continues to gain momentum and wide industry support. The Program has had a significant impact on the level of innovation within the red meat industry and on the competency of industry partners to engage in effective outcomes-focused R&D.

From - MLA Corporate Plan (2002). Progress Report for the period ending 31 December 2001, March 2002.