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Business plan for development and implementation of PASTUREPLAN™

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EXECUTIVE SUMMARY

Meat and Livestock Australia (MLA) and the broader livestock industry are concerned that market failure exists in the development and adoption of improved pasture cultivars in the pastoral, high rainfall and wheat-sheep zones. This view contrasts with that of other stakeholders who believe that conventional pasture breeding has been effective, particularly for the major pasture species, and further investment is no longer required. The consumer (pasture grower and livestock producer) has been unable to drive change through product choice, as the seed market is not differentiated on genetic quality.

The level of genetic improvement achieved in pastures has been disappointing, despite significant investment in breeding by State and Federal governments, and private bodies. There are a number of issues contributing to this poor performance and the limited adoption of improved genetics: the pastures industry is fragmented, breeding strategies are poorly documented without clearly defined economic breeding objectives, objective performance data is lacking, analytical methods are sub-optimal, seed markets are diverse in nature and relatively small on a global scale, public utilities are shifting resources away from pasture breeding, poor coordination of the public effort with a research rather than commercial focus prevailing, and Plant Breeders Rights while stimulating investment also encourages fragmentation.

We acknowledge that breeders and research scientists have done some good work in pastures, but also recognise there is considerable scope for a better understanding of genetics and its application in pasture breeding. Expertise in quantitative genetics is lacking in the industry and the necessary tools and systems are not available to compensate for this deficiency. Although it is encouraging that many stakeholders are receptive to change, structures and technologies must be put in place to facilitate this process.

Despite the mediocre performance of pasture programs, there are a number of opportunities for improvement. However, a coordinated approach by the various stakeholders is needed if we are to capitalise on these opportunities. This will include strategic and technical input from other plant and animal industries. Cooperation is needed as companies and agencies servicing individual breeding programs do not have the critical mass of personnel with the necessary skills in quantitative genetics and breeding

It is recommended that an industry body (Pastures Australia) be established to provide a forum to facilitate an integrated approach to pasture improvement. Stakeholders (livestock industries, RDC's, research agencies, agribusiness and marketing agents, seed suppliers and grain merchants and pasture breeders) will need to be flexible, and approach the business from a fresh perspective. The RDCs can provide the stimulus for change, by coordinating their investment towards a common objective. It is cost effective and strategically important for MLA to lead this change and encourage the establishment of Pastures Australia. Pastures Australia must provide a framework for a coordinated effort in pasture improvement, and avoid the pitfalls of similar efforts in the past. The entity should aim to be financially independent and have business structures in place that will provide flexibility and ensure commercial fitness. A coordinated effort at the national level is required to improve efficiencies, consolidate the genetic resource(s), and improve the competitiveness of an otherwise opportunistic approach to breeding and cultivar development.

The immediate goals of Pastures Australia should include: implementation of a national PASTUREPLAN™ genetic evaluation system, define the breeding objective(s) in economic terms, identify weaknesses in technical strategies for breeding, consolidate data and pedigree information in national databases, produce accurate genetic values for breeding and cultivar release, improve protocols and efficiencies in testing of cultivars, better define the target production environments, promote the use of improved genetics, help coordinate research on a national basis and provide researchers with better access to the genetic resource (public and commercial), reduce cost structures and improve output of the scientific resource, and increase competitive advantage of livestock enterprises through improved pastures.

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Improve the competitiveness of the livestock industries through genetic improvement in pastures.

Position Statement

Historically, there has been significant investment in Australia in genetic improvement programs for the major pasture species of lucerne, white clover, perennial ryegrass, subterranean clover and the annual medics. Public agencies and industry also continue to invest in research activities targeting plant improvement in pastures, including the development of alternative and novel species. Despite good progress, there is considerable scope to improve the effectiveness of the breeding programs and, more importantly the delivery of better genetics (cultivars) to the pasture industry.

Industry has identified that market failure exists in the development and adoption of improved cultivars in the pastoral, high rainfall and wheat-sheep zones. There are a number of issues contributing to the problem:

- There is no objective system in Australia for the genetic evaluation of pastures,
- Livestock and pasture producers have limited objective performance data available for making pasture selection decisions,
- The pasture industry is fragmented with many independent pasture growers, seed merchants and livestock producers,
- Public utilities are divesting of breeding activities, with private companies and multi-nationals taking a more active role,
- The market in Australia is perceived as being small on a global scale for pasture seed, particularly subterranean clover and the annual medics,
- Genetic improvement in pastures, which includes breeding and deployment, has tended to be episodic and lacking in commercial focus,
- Although research has been of a high standard, efforts have not been coordinated effectively, and there has been a tendency to pursue ‘fashions’ to the detriment of conventional breeding,
- Planning and strategy development in pasture breeding has been done on an *ad hoc* basis, and without formalised strategies, budgets and auditing of return on investment, and
- Plant Breeders Rights is becoming increasingly important in protection of IP and encouragement of investment, but can also encourage fragmentation and the opportunistic release of ‘untested’ cultivars.

In summary, there is a need for a coordinated approach to genetic evaluation in pasture species on a national basis.

Proposal

The Research and Development Corporations (MLA, AWI, Dairy Australia, GRDC and RIRDC) consider they should play some ongoing role in improvement of pastures and pasture plants, but question the value of current investments. The RDCs as a group, are seeking to avoid duplication and coordinate investment in pasture improvement on a national basis with the objective of delivering greater benefits to their respective stakeholders.

Although there is considerable activity in pasture breeding, both public and private, there exists several opportunities to value add to the existing investment and effort.

The proposal is to establish a forum (Pastures Australia) that will facilitate an integrated approach to genetic improvement in pastures, both on a technical and commercial basis.

Background

Meat and Livestock Australia Ltd (MLA) has commissioned the Southern Tree Breeding Association Inc. (STBA) to study the feasibility of implementing a national genetic evaluation system for pasture plants.

MLA is a producer owned company that provides services to the Australian red meat industry including producers, processors, exporters, live exporters and retailers. MLA's core activities are improving market access, building demand for Australian red meat and conducting R&D to provide competitive advantage for the industry.

The STBA is an industry funded tree improvement cooperative that breeds genetically improved trees for plantation forestry in Australasia. STBA has developed, in partnership with the livestock industry, TREEPLAN® software suitable for national genetic evaluation for trees and plants. The current study will determine the suitability of this software for genetic evaluation of pasture plants (PASTUREPLAN™), including a strategy for its implementation.

MLA also recently commissioned a review of MLA's investment in pasture evaluation and improvement (Lazenby, Wolf and Chudleigh, 2002). It is not the intention of the current study to review this work, but its findings will be considered where appropriate.

The current study is more specific in its objective, and will focus on genetic evaluation.

Investment in pasture breeding has changed considerably in the past decade with the public sector seeking to divest its traditional role in this area. Its preferred position is for private industry to undertake pasture breeding in the commercial sector. In recent times, government agencies (State and Federal) and the Research and Development Corporations (AWI, DRDC, GRDC, MRC and RIRDC) have continued to fund pasture improvement and associated research, but this effort has lacked coordination and is failing to deliver an acceptable return on investment. It is also difficult for rationalisation and change to occur in public utilities where performance is not linked to commercial outcome and a 'public good' culture is entrenched. Although many breeders and researchers from the public sector are receptive to change in principle, their business and operating environments are impediments. Marketing hype associated with biotechnology has also made it difficult for conventional breeding to be an attractive investment in a tightening market. This is despite genetically modified pastures having had no impact to date on pasture productivity.

The current practices associated with performance testing and evaluation of new pasture cultivars for commercial release is clearly deficient. Cultivars are released with minimal performance data, making it difficult to make objective decisions when purchasing seed. Furthermore, cultivars are not routinely screened under the target production environments, relying on data from other districts or overseas. This lack of objective performance data on cultivars limits the adoption of improved genetics as well as increasing the risk of market failure.

The industry generally acknowledges there is a need for a national testing program.

The Industry

The pastoral industry in Australia is reportedly worth about $10 billion per annum with dairying about $2 billion.

The numbers of cattle in Australia in 2004 have been estimated at 27.1 million (24 m beef). Beef and veal production was about 1.95 million tonne. The value of beef exports of 832 kt is about $3.72 billion. The major markets are USA, Japan and Korea with about 820,000 live cattle exported to Asia, North Africa and the Middle East. Competition is likely to increase from South America (Uruguay, Argentina and Brazil). Sheep numbers are about 104 m, with lamb and mutton production of 330 and 292 kt, respectively. Flock structures are changing with lamb sales contributing a growing proportion of revenue. Exports of lamb are 133 kt and mutton 160 kt, with about 5.5 m live sheep exported to the Middle East (see ABARE 2003). The gross value of cattle, sheep and lambs is about $7.68 billion. Cattle and sheep are predominantly grown on pastures, supplemented by grains and fodder crops. About 2.1 m cattle are grain finished (nearly half for domestic market).

Production Environments:

The pasture feed base has been segregated (ABARE, 2004) into broad production system types:

Pastoral Zone: Includes most of the northern tropical areas and the arid and semi-arid regions of Australia. There is extensive grazing of native pastures. Cropping is impractical due to low rainfall.

High Rainfall Zone: Coastal belt and adjacent tablelands of three eastern States, small areas in south eastern South Australia, and south western WA, and most of Tasmania. Characterised by higher rainfall, steeper topography, adequate surface water and higher humidity.

Permanent pastures are infrequently replaced (and expensive).

Management focus is on fertiliser, subdivision, grazing, stocking rate and weed control.

Lack of persistence and establishment costs are issues.

Increasing adoption and utilisation of deep rooted perennials.

Some interest in low input native grasses.

Species include: legumes white clover (*Trifolium repens*) and subterranean clover (*T. subterraneum*), and perennial grasses (phalaris, cocksfoot, perennial ryegrass and tall fescue). Native grasses such as wallaby grass (*Astrodanthonia* spp.), red grass (*Bothriochloa* spp.) and weeping grass (*Microlaena stipoides*) cover about half the area.

Since 1990, it is claimed the introduction of new cultivars of perennial grasses and legumes have not markedly improved productivity or sustainability of red meat production (Lazenby *et al.* 2002). However, superphosphate, lime and stocking rates have impacted on productivity.

Wheat-Sheep Zone: Climate and topography allow regular cropping of grains in addition to the grazing of sheep and beef cattle on a more intensive basis than pastoral zone. Rainfall is generally adequate for producing a variety of pasture species, usually as part of a crop-grazing rotation.

Northwest 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 wheat-sheep zone can be further differentiated on the basis of agro-ecological zones by GRDC, including WA Mallee and Sandplain; WA Northern Zone; WA Eastern Zone; WA Central Zone; SA Midnorth-Lower Yorke, Ayre; SA Vic Mallee; SA VIC Bordertown-Wimmera; VIC High Rainfall, TAS Grain Areas; NSW VIC Slopes; NSW Central Zone; NSW North West Qld South West; Qld Central Zone; and NSW North East Qld South East. Regional needs might cover: summer dominant rainfall zone, high rainfall zone, acid soils zone and alkaline soils zone.

Pasture management skill base is low.

Legume content is poor and relies on residual fertiliser.

Species include subterranean clover, annual medics and lucerne (*Medicago sativa*). The pasture improvement programs have been effective in producing cultivars with impact.

NAPLIP for annual legumes reduce inputs in sub clover and annual medics, towards balansa clover (*T. michelianum*), yellow serradella (*Ornithopus compressus*) and French serradella (*O. sativus*), biserrula (*Biserrula pelicinus*), gland cover (*T. glandiferum*), and perennial legume sulla (*Hedysarum spp.*).

(a) Crop Specialists (about 42% pasture)

(b) Mixed Livestock Crop Enterprises (about 61% pasture)

North West Slopes and Plains:

Summer dominant rainfall (600 to 750 mm)

Species mainly lucerne and promise of sulla.

Needs drought tolerant perennial legume and sub-tropical grasses.

Mallee regions of SA and Victoria:

Performance of annual medics is unsatisfactory due to management, with vetch (*Vicia saliva*) and oats interest.

GENETIC IMPROVEMENT IN PASTURES

The fundamental elements of a pasture improvement program should include:

(a) a clear definition of the breeding objective,

(b) an adapted species (or inter-specific hybrid),

(c) heritable genetic variation for traits of interest,

(d) an effective breeding program,

(e) rigorous testing of genetic material in target production environments,

(f) efficient data recording and management systems,

(g) data analysis and 'best practise' genetic evaluation using all relevant performance data and information,

(h) early identification of elite genotypes for commercial deployment and further use in breeding,

(i) efficient and cost effective deployment systems for delivering improved genetics to industry,

(j) effective monitoring of commercial performance of released cultivars, and

(k) an effective and relevant R&D strategy.

A dynamic and effective plant improvement program should address each of these elements, and the strategy should be documented and reviewed on a regular basis. This process will assist in identifying weaknesses, overcoming 'bottlenecks' and monitoring performance.

Definition of the breeding objective

In general, the breeding objective(s) used in pasture breeding have been loosely defined in biological terms, rather than in economic terms.

The traits included in breeding objective functions should be those that impact on profitability in the red meat, wool and dairy industries. Unfortunately, breeders often confuse measured traits (eg. stolon length, leaf area index, flowering propensity) with breeding objective traits (eg. palatability, annual biomass, and animal products produced). Resources can be wasted by chasing too many biological traits, some of which have little impact on economic performance and profits derived from pasture products. Breeding objective traits, which are those that influence profit, are often difficult and/or expensive to measure in pasture improvement programs, and correlated selection criteria are used as surrogates. Negative genetic correlations among traits can also make it difficult to simultaneously improve many traits.

A formal definition of breeding objective functions in economic terms is required for all pasture species.

Pasture species adapted to production environments

There is a diversity of production environments in Australia where pastures are grown and a suitable species or mix of species is needed for each one. Fortunately, there are many pasture species currently available with varying degrees of adaptation and productivity for a range of environments in which cattle and sheep graze. White clover, lucerne and perennial ryegrass dominate the global market for temperate agriculture. Other species like subterranean clover and medics although important in Australia, are considered novel species in international markets. As a consequence, multi-nationals may not be interested in breeding for these relatively small and diverse markets.

There is a perception in Australia that conventional pasture breeding in the major species has been effective and further investment is no longer required to develop more cultivars. We do not support this contention, but believe that conventional breeding could be done much more effectively in most pasture species. There is a large amount of heritable genetic variation for plant characters in pasture species that is currently underutilised. Other minor species also offer opportunities for conventional breeding, but efficient and effective strategies must be adopted if investment is to be justified. In conclusion, it is private enterprise that should fund breeding and pasture improvement activity in the future, as public utilities continue to retreat from their traditional role in this area.

Heritable genetic variation for traits of interest

Most pasture species display considerable variation and phenotypic plasticity for a range of biological traits. However, for pasture breeding to be effective some of this observed phenotypic variation must be heritable. Unfortunately, there are some breeding programs that still rely heavily on phenotypic mass selection to improve populations, without regard to the nature of inheritance of the traits. Selection is likely to be ineffective under these circumstances, particularly where traits have a low heritability on an individual plant basis. Furthermore, all available data and pedigree information should be used in genetic evaluation, otherwise genetic gain will continue to be compromised. Although non-additive effects can be important in the deployment of families and clones, it is additive genetic variation that is needed for population improvement.

An effective Breeding Program

Improvement in pastures in the short-term can be made by selection of genotypes (species, ecotypes, populations, families and individuals) already existing within the species complex (exploit existing variation). The introduction of accessions in pastures has been a common practise, followed by selection among and within lines to identify superior genotypes. This approach has met with some success. The enthusiasm shown by breeders for chasing accessions introduced from overseas is fundamentally important in establishing a founder population at the start of a pasture improvement program, but it is not sufficient. There has been too much focus on sampling accessions from the natural range of some species, and on establishing genetic resource centres, at the expense of generation wise breeding. Cross-pollination and breeding among selections (superior genotypes) is a fundamental requirement to generate new gene combinations necessary for ongoing population improvement.

We accept that the biological models differ among the main pasture species: the legumes including lucerne (*Medicago sativa*), white clover (*Trifolium repens*), subterranean clover (*T. subterranean*), medics (*M. trunculata*, *M. littorallis*, *M. polymorpha* and *M. tornata*), and grasses including: perennial ryegrass (*Lolium perenne*), cocksfoot (*Dactylus glomerata*), tall fescue (*Festuca arundinacea*) and phalaris (*Phalaris aquatica*). Some species are obligate self-pollinators, some partial selfers, and others obligate out crossing, and these biological differences place constraints on the types of breeding and selection strategies that can be used. However, it seems that the use of full sib families in progeny testing has not been exploited sufficiently in the past. Half sib families (polycrosses) are effective in estimating the additive breeding value (GCA) of parents, but selection of elite progeny and ultimately genetic gain is limited due to genetic relationships being unknown on the male side. Pedigree recovery through DNA fingerprinting is possible, but its cost effectiveness is unknown. In the case of testing synthetics and composites, the pedigree is further confounded.

For a breeding program to be effective, pedigree must be recorded and genetic relationships known among individuals. Pedigrees are often confounded in pasture breeding due to the use of breeding cohorts and the pedigree not being recorded when selections are taken. Even when pedigree is known, it is not fully utilised in genetic evaluation.

Effective pedigree and data recording systems are needed for pastures. The web based system that used in tree improvement is an appropriate model, and it also facilitates genetic evaluation.

Rigorous testing of genetic material in target production environments

The performance of a pasture cultivar is influenced by its genetic makeup and the environment (climate, soils and grazing management) in which it is grown. Performance data from genetic trials is used to partition out the effects due to genotype, environment and their interactions.

It is generally acknowledged in the industry that current practices associated with performance testing and evaluation of new cultivars for commercial release, are deficient.

Cultivars are released with minimal objective performance data, making it difficult to make informed decisions when purchasing seed. This occurs because cultivars are not routinely screened under the target production environments. Growers must rely on subjective ‘endorsements’ and recommendations that are based on limited data collected from other districts and/or overseas.

The potential for genotype x environment interaction (GxE) to influence the interpretation of performance data is often acknowledged by breeders. Although testing of cultivars is often done on multiple sites, rarely are statistical analyses of data done routinely on an across site basis. In general, the target production environments are not well defined in pastures.

Environments are broadly segregated for pastures (ABARE 2003) into production system types: Pastoral Zone, High Rainfall Zone and Wheat-Sheep Zone (with crop specialists and mixed enterprises), North West Slopes and Plains, and the Mallee regions of SA and Victoria. Within these zones, there is a diversity of environmental conditions and management systems under which pastures are grown. It is unreasonable to expect cultivars to be developed and tested for all environmental combinations, particularly where conditions are not repeatable from season to season. However, a balanced approach is needed to ensure that suitably adapted cultivars with reliable performance are available for the broader production environments.

There is a tendency in pasture improvement to focus on novel species to satisfy niche environments. A more cost effective alternative may be to extend the range of a broadly adapted species by breeding and selection.

Efficient data recording and management systems

Existing pasture breeding database systems are usually deficient with much data stored on an *ad hoc* basis in numerous files with incompatible formats. When data is properly stored in a database, such as Microsoft Access, the structure is not sufficiently flexible to facilitate statistical analysis and/or genetic evaluation on an industry wide basis. As a general rule, breeders and researchers have been very proficient at handling the biological aspects of plant improvement. It is an exciting and relatively straightforward process to generate large populations of pasture plants for establishment in many trials spread across locations. It is also easy to generate large volumes of measurement data in genetics trials over periods of time. Unfortunately, it is more difficult to collate and process this data using optimal statistical methods on a regular and industry wide basis. Although a deficiency in database software has not helped, weak strategies and ineffective IT support have also contributed to the problem. Often genetics work is done for research purposes and on a project basis. As a consequence, this has lead to a lack of integration and disjointed subsets of data and information.

The purpose of collecting data is to achieve the objective, whatever that might be, and databases must be built with this purpose in mind. A modern database for genetic evaluation should, as a minimum, be flexible to handle all of the peculiarities associated with different species, complex pedigree structures, different experimental designs, and changing assessment protocols for traits over time and space, and it should be fully integrated with appropriate genetic evaluation software. The database should also be web based to facilitate data transfer between distant locations, as well as delivering performance data and genetic values to the client (customer).

This functionality is available in a data management system for trees, which is integrated with TREEPLAN® genetic evaluation software.

Data analysis and genetic evaluation using all relevant performance data and information

Data is often analysed as discrete subsets using sub-optimal statistical methods because ‘industrial strength’ software is not routinely available. This situation has arisen because analytical software has been developed for research purposes, rather than for large scale commercial breeding programs. Results presented from trials that are designed to evaluate the relative performance of pasture cultivars are often deficient, with individual trial means reported. This makes the interpretation of results difficult, and can also be misleading when making recommendations regarding cultivar performance.

Planning and strategy are critical in pasture improvement. We need to ensure that sufficient quality data will be available at the time of analysis, if we are to address the objectives in a statistical sense. Too often we expect to make firm recommendations based on limited data sets with too little information.

The optimal statistical method for large scale genetic evaluation is best linear unbiased prediction (BLUP). It is the preferred analytical method for comparing performance of genotypes across space and time. Genetic evaluation should be done on an industry wide basis for a given pasture species, and should include full pedigree and all relevant data correctly weighted for its quality and source. Traits of interest should not be considered in isolation. A multi-trait analysis of performance data should take account of genetic correlations between traits. Data collected in trials located outside of the defined target region should also be discounted (using across site genetic correlations) in a multi-site analysis to reflect the importance of GxE. This has not been done in pasture breeding on a systematic basis.

This functionality is routinely available in the TREEPLAN® genetic evaluation system and it is likely to have utility for the pasture situation.

Pasture breeders must endeavour to apply the appropriate statistical methods when analysing data. That said, we should not be restricted by perfecting models at a local level. Commercial data at a national level is usually unbalanced and messy, and common sense is required to optimise value and genetic gain. As we will never have access to perfect datasets, we must make best use of all available data at the time.

Early identification of elite genotypes for commercial deployment and further use in breeding

The critical determinants of genetic gain for a trait include selection intensity (population sizes), heritability, phenotypic variation, correlations with other traits, and time. The time factor is often ignored in pasture improvement programs, in spite of its impact on delivery of genetic gain to industry.

Without an effective BLUP genetic evaluation system, it is difficult to identify elite genotypes early in a testing program for fast tracking in deployment, further breeding and/or more rigorous testing. Breeders must usually wait until all data for all traits and genotypes is collected before data is analysed and genotypes selected. It is desirable to analyse data on a regular basis and update genetic values as new data becomes available. Breeders, seed producers, farmers and graziers make pasture decisions at least on an annual basis, and genetic values should be updated accordingly.

Stakeholders tend to consider testing of near commercial cultivars as being separate to progeny or performance testing in breeding programs. With good genetic linkage across trials, we should consider all performance data simultaneously in order to maximise genetic improvement.

Efficient and cost effective deployment systems for delivering improved genetics to growers

Companies producing pasture seed will endeavour to maximise profit margins while maintaining competitive advantage. In general, cultivars are released into the market with minimal objective performance data. Currently, subjective information and grower endorsements based on anecdotal evidence are too often used to promote products in the marketplace. The lack of objective data limits the adoption of improved genetics as well as increasing the risk of market failure. This situation will persist until consumers (growers) are able to better discriminate among cultivars on price and genetic quality.

There is currently a failure in the supply chain for a number of reasons. (1) There has been a significant reduction in direct public funding of pasture improvement in recent decades, and this situation is likely to continue. (2) Public breeding programs have been driven largely by research agendas, with limited focus on commercial outcome. (3) Rationalisation in the global market, with Australia seen as a relatively small market by multi-nationals.

It is unreasonable at the moment to expect seed supply agents to provide quality advice on genetic merit of cultivars to customers, when so much confusion exists in the technical programs.

It is important to maintain some flexibility and allow commercial forces to operate effectively in the market place through seed distribution networks.

In our opinion, pasture breeding and cultivar development should be viewed as commercial activities funded by industry, while investment by public utilities and Research and Development Corporations should focus on issues causing market failure, and/or the development of better tools and technology platforms.

Effective monitoring of commercial performance of released cultivars

The performance of cultivars must be regularly and objectively monitored after release. It is usually impractical to address all likely production scenarios in a cultivar development program and failures or sub-optimal performance may result in the commercial situation. Regular monitoring and feedback from producers is required to capitalise on promising cultivars and/or to minimise losses from cultivars failing to reach market expectation.

An effective Research and Development Strategy

An effective and efficient R & D strategy is needed to underpin pasture improvement programs. We must decide whether research is being done for commercial or public good purposes. This decision depends on who is paying and their objectives. With a tightening of public investment in plant breeding, the objective will take on a more commercial focus. This change will also necessitate a shift in attitude by scientists across the spectrum, if they are to respond and prosper in a more commercial environment. There is need for rationalisation as too many breeders are operating in isolation, without access to the full suite of skills necessary for implementing effective breeding programs. With reductions in total funding over time, breeders have been spread too thinly, making it difficult to deliver an effective service. The breeding and research environment needs to change, and despite individuals being receptive to new models, existing cultures and commitments restrict their capacity to shift.

Structures must be put in place that can accommodate competition and innovation, but also facilitate interaction among scientists, pasture breeders, seed producers and the livestock industries.

General Observations on Genetic improvement in Pastures:

- There is a perception that conventional pasture breeding in the major species of pastures has been effective and further investment is no longer required to develop more cultivars. We do not support this position, but argue that conventional breeding could be done much more effectively in most pasture species, and private industry should fund this activity. There is a large amount of heritable genetic variation for most plant characters in pasture species that is currently underutilised.

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

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

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

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

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

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

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

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

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

- Plant Breeders Rights (PBR) is becoming increasingly important in protection of IP and encouraging investment in cultivar development. Unfortunately, PBR can also encourage fragmentation and proliferation of opportunistic breeders, resulting in the release of many 'untested' cultivars. PBR requirements for DUS testing, particularly uniformity, can also limit the ways in which genotypes are deployed.

- There is a need for a coordinated approach to genetic evaluation in pasture species on a national basis, and the PASTUREPLAN™ model has application in this area.

STRUCTURE FOR A NATIONAL PASTURE BREEDING INITIATIVE

Stakeholders:

Livestock industries:

Red meat (beef and sheep), wool and dairying.

R and D Corporations:

Meat and Livestock Australia (MLA)

Australian Wool Innovation Ltd (AWI),

Dairy Australia

Grains Research and Development Corporation (GRDC),

Rural Industries Research and Development Corporation (RIRDC)

Research Agencies:

Universities, State Departments, CSIRO and Cooperative Research Centres (Dryland Salinity and Molecular Plant Breeding).

Agribusiness and Marketing Agents:

Australian Seed Federation, Plant Breeders Rights Office, NSW pasture variety committee, NZ Grasslands Association and Victorian Grasslands Society.

Seed Suppliers and Grain Merchants:

Heritage Seeds Pty Ltd, Pacific Seeds Pty Ltd (Syngenta), Wrightsons Seeds Ltd, Agricom (New Zealand) Ltd, New Zealand Agriseeds Ltd, SunPrime Seeds and PlantTech Pty Ltd (JV with Seedco Australia Cooperative Ltd). Adelaide Seed Co. Pty Ltd, Australian Premium Seeds Pty Ltd, Auswest Seeds, Booborowie Seeds Pty Ltd, Parkseeds Pty Ltd, PGG Seeds, Progressive Seeds Pty Ltd, Queensland Agricultural Seeds Pty Ltd, SA Seed Marketers Pty Ltd, Selected Seeds Pty Ltd, South East Seeds Pty Ltd, Stephen Pasture Seeds Pty Ltd, Sydney Seeds Pty Ltd, Tymko Seeds, Upper Murray Seeds and JH and EJ Williams Pty Ltd.

Pasture Breeders:

Heritage Seeds Pty Ltd (Barenbrug Netherlands), Pacific Seeds (Syngenta), Wrightsons Seeds Ltd, AgResearch Ltd, Agriseeds Ltd (Barenbrug Netherlands), DFL-TRIFOLIUM (Denmark), Forage Genetics (USA), Pioneer Hi-Bred (Australia) Pty Ltd (Dupont USA), Pristine Forage Technologies, Primary Industries Victoria, Department of Agriculture (WA), NSW Agriculture (Primary Industries), SARDI and CSIRO.

Organisational Structure:

Industry has endeavoured to implement national pasture improvement programs in the past with limited success. When considering new models, it is important to recognise the strengths and weaknesses of these various efforts and also experiences in other species.

The Australian Pasture Plants Evaluation Committee Inc. (APPEC) was established in 1994 for merit testing of a number of legumes and grasses. It was a voluntary scheme supported by the Seed Industry Association of Australia (SIAA) and was established in response to an increasing number of pasture and fodder varieties being marketed within Australia. APPEC was established as an incorporated body responsible for the independent and national evaluation of pre-release pasture varieties from public and private breeding organisations or companies. After deregistration of APPEC, the SIAA was to assume responsibility for maintaining evaluation protocols as part of the Seed Industry's National Code of Practice on labelling and marketing of seed for sowing. Establishment and management of cultivar evaluation trials were no longer to be coordinated nationally, but rather individual companies or their contractors would manage such trials.

The original objectives of APPEC were appropriate: (i) to manage Australian evaluation schemes for pasture grasses, pasture legumes and other pasture plants, (ii) to establish scientific protocols for various stages of evaluation, (iii) to provide data and information on pasture plants to owners/breeders, companies and agencies submitting plants, and (iv) to manage the financial arrangements of APPEC. At the time, it was considered that without an independent organisation providing this information on new material entering the pasture and fodder cultivar market, there was limited opportunity to protect Australian farmers from substandard cultivars. APPEC was to utilise a network of trained professionals to conduct the evaluation, with trials conducted over a two year period for short-lived ryegrasses, and a three year period for all other species, following species specific protocols. APPEC sites were to cover the dairy, prime lamb, beef, cropping and wool growing regions under dry land and irrigated conditions. Species tested within APPEC included perennial ryegrass, short-lived ryegrasses, cocksfoot, phalaris, tall fescue, white clover, lucerne and red clover.

Lessons must be learned from the failure of APPEC (deregistered in June 2002) if national testing and evaluation is to be supported in the future. Likely contributing factors to its failure were: parochialism, lack of resources, underestimation of the task, lack of commitment and accountability of responsible entities, shifts in government policy and support, a lack of technical tools (national databases and analytical software), the wrong people, lack of scientific rigour, and conflicts of interest among participants and industry. For example, guidelines and protocols for the analysis of trials were deficient, and there was criticism of the design of trials and power of discrimination among cultivars.

The focus of APPEC was on providing objective data for cultivar release. Although this is an important objective in its own right, there exists an opportunity in future to utilise data on advanced cultivars in final stage testing to improve the accuracy of breeding values on relatives in earlier stages of cultivar development. However, for this to occur there needs to be an integrated approach to data collation and processing. Univariate single site analyses are the norm in pasture improvement, and performance under a range of scenarios (irrigated vs dry land, single species vs mixed species swards) is not properly addressed.

The National Annual Pasture Legume Improvement Program (NAPLIP) was formed in 1994 and is currently targeting annual medics, sub-clover and alternative legumes.

The NAPLIP program consumed the NAMIP (National Annual Medic Improvement Program), which was established in the 1980s, and the NSCIP (National Sub Clover Improvement Program). It appears recent effort has shifted to novel species, diverting resources away from sub-clover and annual medics. The programs are project based and have short term goals. There appears to be little coordinated long term breeding for the conventional species of sub-clover and annual medics, despite their widespread utility in Australia.

The Australian National Turf Evaluation Program (formerly AUSTEP) evolved in 1997 to develop and coordinate evaluation trials of turf grass varieties (perennial ryegrass). This program targets a specific market (turf) for varietal testing, uses limited sites, and does not produce genetic values.

It is recommended that Industry should build on existing initiatives (such as NAPLIP) in its continuing endeavour to establish national pasture breeding programs. However, any initiative must be made commercially fit and be provided with the structure, independence and resources necessary to achieve the corporate goals and objectives of its stakeholders. It is unlikely that 'in-kind' contributions to loose unincorporated joint ventures and committees will satisfy this primary requirement. Personnel seconded from public utilities are unlikely to be supported long-term and will continue to have ongoing corporate responsibilities to their parent entity. All stakeholders must have the opportunity to participate in setting goals and technical directions, but management and administrative responsibilities must be sufficiently independent to avoid personal and commercial conflicts of interest.

The existing R and D effort (including breeding) is tired and needs a quantum shift in direction to foster innovation and productivity. In general, participants are willing, but motivation is lacking.

There are models used in other plant and animal systems with objectives in common with the pastures situation.

The Southern Tree Breeding Association Inc. has managed national tree improvement programs for plantation species of *Pinus radiata* and *Eucalyptus globulus*. The STBA was founded in 1983 in South Australia, but has expanded to service tree improvement in Australasia. The tree improvement programs are funded by industry and supported by five research agencies (CSIRO, CRC-Sustainable Production Forestry, Forest Research NZ, Forest Science Centre and Animal Genetics and Breeding Unit). The membership is flexible and is administered under a Constitution. The structure of the Association facilitates scientific excellence through its Technical Advisory Committee, which is made up of representatives from research agencies and industry. The Association with its Board of Management and independent administration (employees) allows the business to be relatively autonomous while clearly focusing on the needs of the forestry industry and its stakeholders. In order to complete genetic evaluation on an industry wide basis, the STBA designed and developed in partnership with the livestock industry, TREEPLAN® genetic evaluation software.

PASTUREPLAN™ because of its systems approach can provide structure and focus to an otherwise disorganised and fragmented effort in breeding and genetics of pastures. Although the plantation forest industry covers some 1.6 M ha, only a small number of companies manage the bulk of the estate. This is in contrast to the livestock industry and other short rotation crops where many producers and growers are involved. This advantage has made it possible to get an earlier consensus on national genetic evaluation and agreement to implement systems like TREEPLAN® in forestry. It should be easier to implement PASTUREPLAN™ genetics in pastures and other crops given this experience, but also because the genetic evaluation methods are leading edge and can deliver a better service to industry at a much reduced cost.

The concept of cooperative breeding in forestry is not shared by all industry parties, and some entities continue to run their own commercial breeding programs. There are various reasons why some entities elect to be partially independent: differentiation in the market place; 'hangover' from State government programs; not valuing the contribution of genetics; and/or preference to buy off the shelf and pay royalties. In other words, one model does not fit all. The STBA must generate a favourable return on investment for such long rotation crops, where returns are often not realised within the lifetime of the decision maker. The STBA breeds for *P. radiata* and *E. globulus*, but also undertakes genetic evaluation on a fee for service basis in other trees and plant species. The TREEPLAN® system was designed with the flexibility to handle different plant species, and is well supported by a web based database for the efficient management of data and pedigree information. It is also well supported by a team of geneticists and researchers with the combined skills to deliver. The objective is to process performance data using best practise genetics and deliver the results to industry efficiently and cost effectively.

The TREEPLAN® system is working well in the forestry industry and PLANTPLAN Genetics Pty Ltd (a wholly owned subsidiary of STBA) is currently developing a business plan to extend the service into other plant species internationally.

GRDC is establishing a National Variety Trials program to give independent performance assessments for new cereal crop varieties prior to their release. GRDC has contracted the Australian Crop Accreditation Systems Limited (ACAS) to manage the National Variety Trials. ACAS was founded in 1997 and incorporated in 2000 as a not-for-profit organisation. Its trustees are GRDC, Grains Council of Australia, Australian Seed Federation (SIAA), Primary Industry Steering Committee (representing State and Commonwealth Government agencies). The NVT replaces current state-based Crop Variety Testing (CVT) programs. The NVT will be a nationally coordinated system for testing of new varieties, with ‘independence’ of NVT trials from breeding program trials. Growers and grower organisations are concerned that varieties could be released with little publicly known information on performance relative to widely grown varieties. Independent crop evaluation is expected to better integrate private breeding programs and agents of imported varieties. NVT will focus on wheat, durum, barley and canola, and subject to funding, pulses grain oats and triticale. CVT testing has been common practice in other countries, and mandatory in Canada and European Union. Participation in the NVT program should remain voluntary, with ACAS endorsing the release of cultivars. With increasing commercialisation of breeding in cereals and other crops, market forces must be allowed to operate unhindered by unnecessary regulation. Despite the benefits for the consumer (growers) associated with national NVT testing, too much regulation may in principle contravene the Trade Practices Act.

GRDC has called for expressions of interest from organisations and individuals to provide evaluation services as part of NVT. Subject to completing negotiations, NVT trials may begin in early 2005, otherwise delayed until 2006. Although the proposed model for NVT testing in cereals has merit, its effective implementation is yet to be realised. There is some concern by interested parties that the services required have not been fully costed and it may fail to deliver on its objectives. There are some positive elements about the structure of NVT, but also concerns with GRDC continuing to be the contracting entity. ACAS Limited will have a General Manager/Coordinator accountable to its board. The requirement for independence of breeding programs may result in inefficiencies, as ACAS and its contractors may not have the suite of technical skills needed for conducting national variety testing. Although financing of NVT trials will be done initially by GRDC, it is also unclear whether this service will be provided indefinitely by GRDC on behalf of growers. It is reasonable to expect the service offered by ACAS to be fully commercialised in due course with full funding by industry.

The NVT program will generate performance data only on varieties close to commercial release. This data will be expensive to generate (full costing in the order of $5-7 M pa nationally) but will aid growers in decision making. It could also be of considerable value to the individual breeding programs in genetic evaluation, if it were integrated with performance data in the early stages testing.

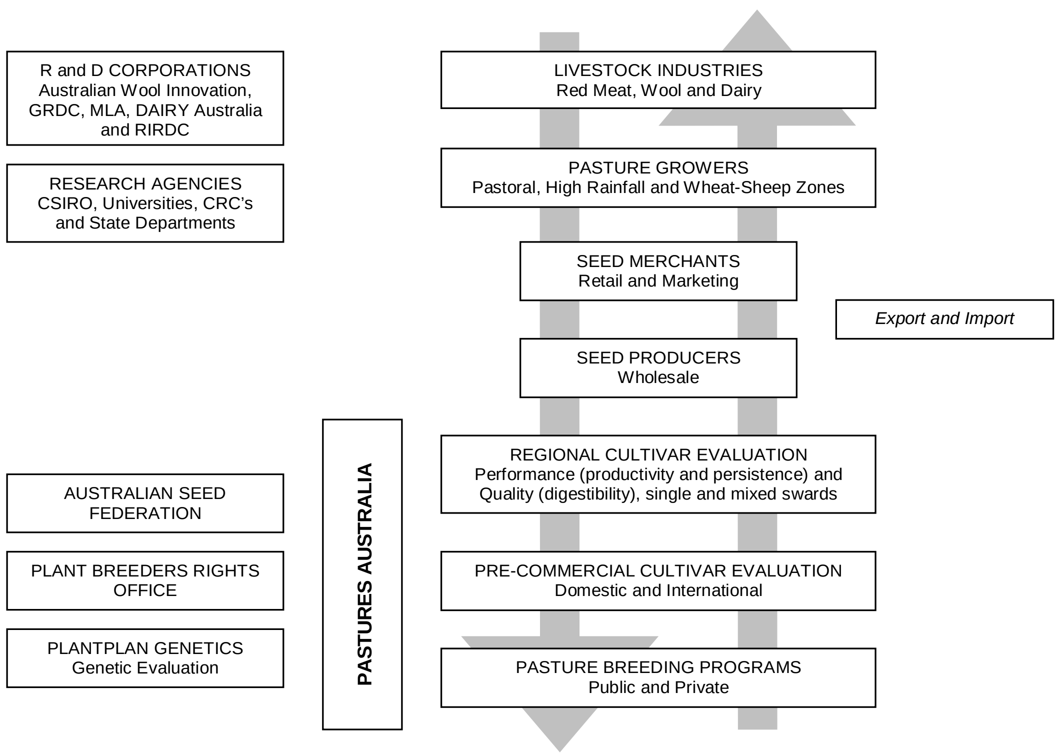
The structure of an entity to service pastures should ensure there is sufficient access to technical expertise to address all aspects of genetic improvement in pastures. In general, there is currently a lack of personnel in pasture breeding with adequate formal training in quantitative genetics. Access to an appropriate skill base must be considered a minimal requirement for pasture improvement. This can be easily resolved by ensuring there is effective communication and interaction among scientists across species contributing to objective decision making. Advice must be accessed from other plant and animal breeding programs, to compensate for current knowledge base deficiencies in pastures.

Pastures Australia

An industry body (Pastures Australia) needs to be established with an appropriate Constitution and By-Laws to operate effectively, and with sufficient autonomy to manage conflicts of interest among its stakeholders. Several models are suitable. It can be formalised as an Incorporated Association or Proprietary Limited Company limited by shares. The relationship of the proposed entity with industry is shown in Figure 1.

The National Pasture Workshop held in May 2004 put forward components of a national coordinated pasture investment strategy for further debate. The components included: shared vision and objectives, market intelligence, economic criteria and analysis, platform technology, plant breeding, commercialisation, agronomic packages, market intelligence, monitoring delivery and evaluation, and RDC coordination and co-investments. The workshop represented the interests of the respective RDCs, but with only limited input from industry. The views of workshop participants were considered in the current proposal.

Figure 1 — Relationship of Pastures Australia with Industry

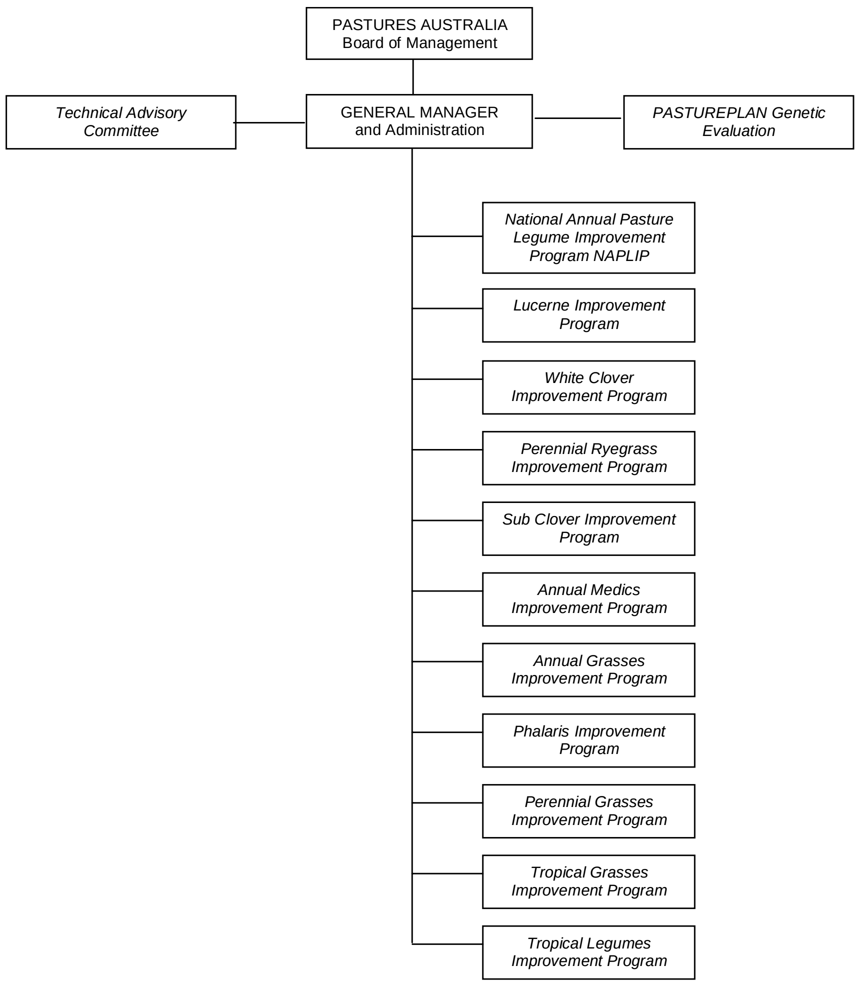


The purpose of Pastures Australia is to provide a forum that will facilitate an integrated approach to pasture improvement, both technical and commercial. Pastures Australia needs to have a structure that encourages participation by all stakeholders (livestock industries, RDC's, research agencies, agribusiness and marketing agents, seed suppliers and grain merchants, and pasture breeders). It should be a coordinating entity to improve information flows (commercial and technical) and facilitate genetic improvement in pastures. It should endeavour to improve the performance of existing capability (public and private) without attempting to 'control' and regulate the marketplace. It should be flexible, and not expect to be attractive to all individual stakeholders. It should be realistic in its corporate objectives and goals, and be aware that pastures and livestock production is a complex socio-cultural process. As such, Pastures Australia may not be able resolve all the issues facing genetic improvement in pastures, but it will provide an opportunity to significantly improve on the current situation.

PASTURES AUSTRALIA

A proposed organisational structure for pasture breeding is shown in Figure 2.

Figure 2 — Pastures Australia Organisational Structure



Vision:

The purpose of Pastures Australia is to:

Improve the competitiveness of the livestock industries through genetic improvement in pastures.

Pastures Australia should operate in accordance within its Constitution (Rules) and Bylaws and relevant Acts and Government regulations. The Constitution should ensure it meets with modern business practises and matches the needs of its members and stakeholders. The goals and objectives should be focused on the essential elements of genetic improvement and not attempt to undertake activities best done by commercial entities and stakeholders. It should focus on overcoming market failure and act as a conduit for information flows. Pastures Australia should be funded by shareholder companies, but with its finances managed independently. A detailed three year Business Plan will be required for implementation.

Goals:

The strategic Business Plan should include the following goals:

- Develop and implement a national PASTUREPLAN™ genetic evaluation system.
- Identify weaknesses in technical strategies for breeding of pasture species.
- Facilitate the storage and retrieval of pedigree and performance data in a national web based database for pasture species.
- Provide accurate genetic values for genotypes in pasture improvement programs for purposes of breeding and/or cultivar release.
- Remove 'bottlenecks' associated with data processing and genetic evaluation and improve the efficiencies of pasture breeding and testing of cultivars.
- Facilitate the deployment of cultivars specifically adapted to defined target production systems and environments.
- Identify opportunities for industry structures that will enhance the development and adoption of genetically improved pastures.
- Facilitate more effective R&D investment in pastures by providing better access to data and improved genetic material.
- Increase the competitive advantage and profitability of the red meat industry (beef, lamb and sheep meat) through improved pastures.
- Reduce costs and improve the efficiency of the scientific resource servicing pasture improvement.

Membership and Shareholding

The membership should be structured to allow participation by all stakeholders with an interest in genetic improvement of pasture species. Membership categories might include: Ordinary Members (Pasture Breeders with an interest in IP and Genetic Material) and Associate Members (Research Members and Seed Merchants). The following are only suggestions and structures should be developed after further consultation with industry.

Board of Management

The Board of Management should determine policy and strategic direction, and set guidelines for the effective operation and management of Pastures Australia. The Board must be small enough to be effective, and should consist of up to seven representatives nominated by the membership. It is not essential that Board members be stakeholders, but they should be nominated for appointment by shareholder companies. The Chairman is elected by and from the Board and establishes sub-committees as necessary for operational efficiency. For best practise and stewardship, the Board may contract the services of independent business advisers as non-voting members. It is important Board members represent the corporate objectives of Pastures Australia, and not necessarily those of their parent companies. The Board should meet at regular intervals (up to four times per year).

Management

A Manager should be appointed to manage the activities of Pastures Australia. It is desirable the Manager, or other personnel under their direction, have high level formal training in quantitative genetics and preferably experience in commercial breeding. In general, existing breeding programs are serviced well in the biological and agronomic aspects of genetic improvement, but are deficient in strategy and analytical evaluation.

Pastures Australia could effectively outsource components of its business, but under tight contractual arrangements. For example, genetic evaluation could be contracted to PLANTPLAN Genetics Pty Ltd which has the tools (web based data management system and PASTUREPLAN™) and experienced team to undertake genetic evaluation on a national basis.

Technical Advisory Committee

The Technical Advisory Committee (TAC) should contribute to the technical excellence of Pastures Australia. Representatives should be nominated by members and ratified by the Board of Management. It should advise on the objectives and breeding strategy by species and review the technical performance of the pasture improvement programs. The TAC should facilitate collaborative research and monitor progress and outcomes of specific projects. Sub-committees can be established to address specific objectives (for example, certification, merit testing protocols, quantitative genetics and breeding strategies, genetic resources and research). The Committee should meet annually (or as the need arises) and make technical recommendations to the Manager for consideration and approval by the Board of Management. The TAC should be elected for a two year term and contain a balance of theoretical, technical and commercial skills among its participants. Members of the TAC should be stakeholders and meet their own expenses associated with travel. The Manager may call on expertise from outside the TAC to participate in particular activities as needed.

Breeding Programs Steering Committees

It may be necessary to establish species (or subgroups) specific Steering Committees to represent the broader industry and ensure that the commercial interests of individual shareholders are represented. Representatives should meet annually (or as necessary) to review progress, revise objectives and recommend budgets for consideration by the Manager and Board of Management. Steering Committees should consider the relevance of recommendations made by the TAC, with reference to species or sector. The NAPLIP or *APPEC* programs would fit within this category, but I suggest all pasture species be considered by Pastures Australia.

Benefit to Stakeholders

What is the value proposition for the private sector?

The establishment of Pastures Australia and the implementation of PASTUREPLAN™ are directed at improving the competitiveness of the livestock industries through genetic improvement in pastures. The benefits that can accrue from genetic improvement in pastures are straightforward for the red meat, wool and dairy industries. A more productive feed base which is of better quality can lead to greater profits and a higher return on investment.

For the Research and Development Corporations (MLA, AWI, Dairy Australia, GRDC and RIRDC), breeding and genetics is a relatively low risk strategy capable of delivering a solid return on investment for their respective shareholders.

Research agencies (Universities, State Departments, CSIRO and Cooperative Research Centres) with capability in pasture genetics continue to rely on public, and to a lesser extent private revenue streams for supporting fundamental and applied research. Pastures Australia and PASTUREPLAN™ will facilitate some much needed rationalisation and realignment of research efforts.

Agribusiness and marketing agents (Australian Seed Federation, Plant Breeders Rights Office and grasslands societies) will benefit from increased trading and activity associated with commercialisation of cultivars.

Interest in pasture breeding and associated research by seed suppliers and grain merchants is less clear. Changeover costs for seed suppliers with established pastures that are producing good quantities of 'saleable' seed at low cost will be a disincentive for the adoption of new cultivars in an uncompetitive market. However, access to improved cultivars might increase overall demand for seed by encouraging pasture growers to establish better pastures and rejuvenate existing areas. In a healthy marketplace, we could expect improved genetics to confer competitive advantage to the more progressive seed suppliers. When cultivars in the marketplace cannot be differentiated on the basis of genetic quality, market failure will result as consumers (pasture growers) are unable to exert pressure through purchasing preference. Grain merchants, subject to industry trends, should be relatively responsive to market forces of supply and demand. Investment in improved genetics will be of benefit if it can stimulate sales and increase turnover in pasture seeds.

The motivation for private pasture breeders to buy into Pastures Australia and/or invest in PASTUREPLAN™ genetic evaluation is more complex. Although the pasture seed industry in Australia is worth about $70 M pa, it is considered relatively small on an international scale. As such, multi-nationals will focus their efforts on the larger and more lucrative markets of North America and Europe, exploiting Australian sales in an opportunistic manner. Target production environments for the local market are also diverse, requiring a broader portfolio of species and cultivars. Pasture breeding is expensive and returns lag behind investment. A further disincentive for participation and investment by private industry in pasture breeding is direct competition from public utilities. As this public investment is not rigorously audited, breeding is effectively subsidised by the taxpayer. Private industry will also resist paying upfront while the public continues to fund pre-commercial breeding efforts. This position is rapidly changing with public utilities increasingly moving out of commercial breeding, preferring to invest in developing platform technologies.

While there are some commercial reasons why private pasture breeders may resist the concept of Pastures Australia and/or PASTUREPLAN™, there are some compelling arguments for their participation.

- Independent endorsement of proprietary products (cultivars) and product differentiation.
- Industry support (resources) to assist with provision of objective performance data for commercial cultivars.
- Capacity to charge more for superior genetics.

- Reduced chance of market failure, and less potential for litigation.
- A more focussed portfolio of products to support (reduced costs).
- Fewer resources will be wasted in testing and multiplying genetic material that is unlikely to make the grade.
- Demand for improved pasture seed will increase and there should be a broadening of the market, as satisfied customers (farmers) will seek to upgrade more of their pastures more often.
- Coordinated testing and evaluation will lead to improved efficiencies at lower cost.
- Reduced costs in private breeding programs, thus more gain from investment.
- Enhanced R and D capability and relevance, whether public or privately funded.
- RDC's (MLA and others) to mostly fund implementation and establishment of PASTUREPLAN™ – Minimal risk to the private sector with ongoing maintenance costs lower than conventional methods.
- Private sector will be better able to target global breeding and cultivar portfolio. (International genetic evaluation is feasible).
- Parent companies (Barenbrug and others) have opportunity to access leading edge genetic evaluation tools. Complex genetic evaluation made easy.
- Private companies have enhanced ability to maintain market share in Australia. They will be able to maintain a competitive edge with other European and North American companies that opportunistically export seed and/or cultivars to Australia currently without the cost of cultivar development (breeding and testing).
- Rationalisation of the market with inefficient players (including public utilities) being forced out of the market. They will not be able to continue to penetrate the market with 'opportunistic' cultivars with mediocre performance in an increasingly competitive market.
- The capacity to protect IP through Plant Breeders Rights will be enhanced and encouraged by industry.
- Feedback and information flows from customers through to basic research will be facilitated in a more efficient forum.
- Access to genetics expertise at lower cost through the Technical Advisory Committee (and PLANTPLAN Genetics). Reduced cost structures as the systematic approach to genetic evaluation reduces the dependency on specialised geneticists.
- Access to expert plant and animal geneticists from other industries will complement the skill base of pasture breeders.
- Integrated and systematic management of data and information through a secure web based data management system should facilitate operational efficiencies across regional and international boundaries.

MEAT AND LIVESTOCK AUSTRALIA

Recommendation(s):

MLA should negotiate with other RDC's (AWI, Dairy Australia, GRDC and RIRDC) for agreement in principle to participate in the establishment of Pastures Australia. It is recommended that the RDC's contribute financially to the establishment and operating costs (for an initial period of up to three years) to ensure the entity is commercially viable. After this initial period, the RDC's can reduce their financial support over time as the industry takes responsibility for undertaking what should be seen as essentially commercial activities. Pastures Australia should provide a forum for identifying and evaluating research opportunities on a collective basis, as well as minimising duplication and facilitating adoption. This process will assist the RDC's in determining their level and area of commitment to pasture improvement. Although it is not essential that each RDC continue an active and financial role in Pastures Australia, it is probably valuable in a strategic sense.

Action: *MLA to meet with other RDC's in September 2004 to discuss business structures and their commitment to participate in Pastures Australia.*

Research Projects should be formalised that address fundamental weaknesses in the technical strategies of pasture breeding programs.

Breeding objectives will need to be clarified and defined in economic terms. In the first instance, the major commercial species with existing breeding programs should be targeted (Lucerne, White Clover, Perennial Ryegrass, Subterranean Clover and Annual Medics).

Action: *Develop projects to define breeding objectives in economic terms.*

Breeding and selection strategies should be formally reviewed by the Technical Advisory Committee with input from external scientist's who are expert in breeding and quantitative genetics, including plant and animal breeders. There should be a review of national protocols for testing and cultivar evaluation. However, this activity should be ongoing and not delay progress in other key areas.

Action: *Establish Pastures Australia with a Technical Advisory Committee.*

Data management and genetic evaluation need to be addressed as a matter of urgency. Without access to modern analytical tools like PASTUREPLAN™, options for breeding, testing and genetic evaluation will remain severely restricted. It is likely that much of the existing data collected to date is of limited value in genetic evaluation, but structures should be put in place that consolidate historical trial data as well as facilitate proper recording and storage in the future. There is a risk that valuable genetic material and information will be lost with public utilities withdrawing from their role in population improvement for the major pasture species. It is also important that current investment by RDC's in the development of novel species is protected by securing data in a modern web based data management system accessible by the relevant stakeholders. It is also desirable that the adopted data management system be fully compatible with genetic evaluation software to facilitate future updates of genetic values on a national basis. Systems that are working in plants should be considered for this purpose. There is a temptation for stakeholders to build their own 'in-house' systems, but this can be distracting, inefficient and costly. There are products in the market that can be utilised. For example, the TREEPLAN® genetic evaluation system is fully integrated with the web based STBA-DMS, and this could be made available as part of a PASTUREPLAN™ genetic evaluation service through PLANTPLAN Genetics Pty Ltd.

Note: ***An effective genetic evaluation system coupled to national databases should act as a conduit to overcome many of the inherent weaknesses existing in pasture plant improvement.***

A contract should be considered with PLANTPLAN Genetics Pty Ltd to consolidate genetic material and data and undertake genetic evaluation in at least one of the major pasture species, subject to support from industry and breeding agencies. The databases should be accessible via the Internet, and have appropriate security protection to ensure Intellectual Property of the various stakeholders is protected. This project will refine technical requirements and modify existing plant genetic evaluation (TREEPLAN®) software to handle the genetic and pedigree structures peculiar to pasture plants. The forestry industry is currently investing $1.4 M into the enhancement of the TREEPLAN® system which is used for national genetic evaluation in the plantation species of *Pinus radiata*, *Eucalytus globulus* and *E. nitens*. There is an opportunity for the pasture industries to value add to this strategic investment.

Action: *Develop a project with PLANTPLAN Genetics Pty Ltd and industry to establish web based databases for the major pasture species (Lucerne, white clover, perennial ryegrass, sub clover, annual medics, and other active programs including phalaris).*

Budgets:

Costs for software development and implementation are indicative only at this stage. Detailed budgets will be prepared as strategic directions are set by MLA and other parties. It should be noted that the pastures industry does not have the skill base 'in-house' to build the tools which are necessary for national genetic evaluation.

Legal Costs for establishing Pastures Australia

Pastures Australia incorporation:	Costs to formalise the industry body including: determining the appropriate entity structure, establishing a formal set of rules (Constitution and Bylaws) with industry ownership and establishing a governing Board of Management ($30,000 to $50,000).

Costs for establishing a national PASTUREPLAN™ genetic evaluation system

PASTUREPLAN™ software:	Develop a PASTUREPLAN™ variant (AGBU be contracted to undertake modification of TREEPLAN® software) with technical input from STBA and PLANTPLAN Genetics Pty Ltd ($50,000 to $100,000). Modifications to data management software (STBA-DMS) and licenses for use to be finalised. Interfaces designed to incorporate styles and company logos of Pastures Australia and stakeholders.
Data base development:	$10,000 plus $40,000 (software engineers and PLANTPLAN Genetics Pty Ltd) customisation per species.
Populate databases:	$50,000 to $100,000 per species with 'in-kind' assistance from breeding organisations (PLANTPLAN Genetics Pty Ltd and industry).
PASTUREPLAN™ genetic evaluation:	Two year project $150,000 pa per species (PLANTPLAN Genetics Pty Ltd).
Strategy review and documentation:	$50,000 per species.
Development of economic breeding objectives:	$250,000 per species (efficiencies with multiple species)

Note: *The TREEPLAN® genetic evaluation system is being commercialised by STBA (PLANTPLAN Genetics Pty Ltd) under license as a bureau service to clients with large scale improvement programs in trees and other plant species.*

Pasture Species:

Perennial Grasses:

Perennial ryegrass (*Lolium perenne*), Cocksfoot (*Dactylis glomerata*), Tall Fescue (*Festuca arundinacea*) and Phalaris (*Phalaris aquatica*);

Perennial Legumes:

Lucerne (*Medicago sativa*), White clover (*Trifolium repens*) and Birdsfoot trefoil (*Lotus corniculatus*);

Annual Grasses:

Italian Ryegrass (*Lolium multiflorum*) and Annual ryegrass (*L. rigidum*);

Annual Legumes:

Subterraneum clover (*Trifolium subterraneum*), Barrel medic (*Medicago truncatula*), Strand medic (*Medicago littoralis*), Burr medic (*Medicago polymorpha*), Disc medic (*Medicago tornata*), Biserrula (*Biserrula pelecinus*), French serradella (*Ornothopus sativus*), Gland clover (*Trifolium glanduliferum*), Balansa clover (*Trifolium michelianum*), Yellow serradella (*Ornithopus compressus*), *Lotus ornithopodioides* and Persian Clover (*Trifolium resupinatum*);

Other species include:

Lotus Major (*Lotus pedunculatus*), Kikuyu (*Pennisetum clandestinum*), Paspalum (*Paspalum dilatatum*), Snail medic (*Medicago scutellata*), Gama medic (*Medicago rugosa*), Red clover (*Trifolium pratense*), Clustered clover (*Trifolium glomeratum*), Woolly clover (*Trifolium tomentosum*), Small white clover (*Trifolium nigrescens*), Moroccan serradella (*Ornithopus isthmocarpus*), Purple clover (*Trifolium purpureum*), Berseem clover (*Trifolium alexandrinum*), Hairy canary clover (*Dorycnium hirsutum*), Murex medic (*Medicago murex*), Sulla (*Hedysarum coronarium*), White sweet clover (*Meliotus alba*), Pink serradella (*Ornithopus sativus*), Cupped clover (*Trifolium cherleri*), Helmet clover (*Trifolium clypeatum*), Eastern Star clover (*Trifolium dasyurum*), Rose clover (*Trifolium hirtum*), Crimson clover (*Trifolium incarnatum*), Moroccan clover (*Trifolium isthmocarpum*), Bladder clover (*Trifolium spumosum*), Arrowleaf clover (*Trifolium vesiculosum*), Trigonella (*Trigonella balansae*), Brome grass, Buffel grass (*Cenchrus ciliaris*), Rhodes grass (*Chloris gayana*), Urochloa, Indian Blue grass (*Bothriochloa pertusa*), Setaria grass (*Setaria sphacelata*), Digit grass (*Digitaria eriantha*), African Lovegrass (*Eragrostis curvula*), Bahia grass (*Paspalum notatum*), Purple Pidgeon grass (*Setaria incrassata*), Creeping Blue grass (*Bothriochloa insculpta*), Jarra grass (*Digitaria milanjiana*), Signal grass (*Brachiaria decumbens*), Tully grass (*Urochloa humidicola*), Guinea grass (*Panicum maximum*), Stylosanthes spp., Burgundy Bean (*Macroptylium bracteatum*), Wynn Cassia (*Chamaecrista rotundifolia*), Cavalcade (*Centrosema pascuorum*), Siratro (*Macroptilium atropurpureum*), Glycine (*Neonotonia wightii*), Milgarra Butterfly Pea (*Clitoria ternatea*), Forage peanut (*Arachis pintoi*), Vigna (*Vigna parkeri*), Prairie grass, Common vetch (*Vicia sativa*) and Wooly pod vetch (*Vicia villosa*).

Fodder crops:

Oats (*Avena sativa*), Winter wheat (*Triticum cestivum*), Triticale, Cow peas (*Vigna ungulkculata*), Forage sorghum (*Sorghum spp.*), Millet (*Echinocloa utilis*), Maize (*Zea mays*), Rape (*Brassica napus*), Turnips (*Brassica rapa*) and Fodder radish (*Paphamus sativos*).

Herbs:

Plantain *(Plantago lanceolata)* and Chicory *(Cichorium intybus).*

TREEPLAN® TECHNOLOGY

The Australian forest industry has implemented the TREEPLAN® system for genetic evaluation of plantation tree species on a national basis. This plant based model is used in multiple species and has particular utility for pastures. It is leading edge and utilises 'best practice' genetic technologies.

BLUP is the preferred analytical method for comparing the performance of genotypes across space and time. BLUP methods are well developed theoretically for plants, but public domain software in general has been suitable only for research purposes and/or breeding value estimation on small and/or well structured data sets. This lack of BLUP software had acted as an impediment to national tree breeding programs in Australia, until the development of the TREEPLAN® system. The Southern Tree Breeding Association Inc (including its research members) and AGBU have developed the TREEPLAN® software specifically for application in tree and forestry improvement. The project combined well developed plant and animal breeding technologies (BREEDPLAN) into an analytical software package designed for calculating genetic values in trees. Considerable development was required as the biological, genetic and statistical models of trees and plants differ significantly from those of animals. The STBA and AGBU are currently enhancing the TREEPLAN® system to incorporate DNA information, spatial analysis of environmental effects, modelling of non-additive genetic effects at the individual level, and better methods for handling genotype by environment interaction. TREEPLAN® V1 fits an additive genetic model, with non-additive effects (specific combining ability) fitted at the family level. The statistical model is a mixed linear model. A multi-generation, multi-site, multi-age and multi-trait model is usually fitted. Genetic values are produced specifically for the different production regions, but correctly weighted depending on the source location and quality of data.

It is likely that modifications to the TREEPLAN® system will be needed to handle data and pedigree structures (synthetics, lines and hybrids) peculiar to pasture plants and other crops. The TREEPLAN® system is routinely used by the STBA for national genetic evaluation in the major plantation species of *Pinus radiata*, *Eucalyptus globulus* and *E. nitens*. The STBA has also designed and built a powerful, but flexible web based data management system (STBA-DMS) to store and retrieve performance data and pedigree information on trees and plants. More importantly, the STBA-DMS™ is integrated with the TREEPLAN® system to facilitate genetic evaluation and to provide regular updates of genetic values as information accumulates. The dynamic nature of the system and the web based interface facilitates the processing of data from remote and regional locations as part of the national evaluations. The STBA-DMS™ also facilitates delivery of information to industry, including objective performance data on genotypes, via the Internet. Security of IP and information is paramount, with password protection allowing clients to access only designated information.

REFERENCES:

Kerr, R.J., Tier, B., McRae, T.A., Dutkowski, G.W. and Apiolaza, L.A. (2001). TREEPLAN™ – A genetic evaluation system for forest tree improvement. In Developing the Eucalypt of the Future. IUFRO International Symposium, Valdivia, Chile, 10-15 September 2001.

Kerr, R.J., Dutkowski, L.A., Apiolaza, L.A., McRae, T.A. and Tier, B. (2002a). Developing a genetic evaluation system for forest tree improvement – The making of TREEPLAN®. In: Seventh World Congress Applied to Livestock Production. Montpellier, France 19-23 August 2002.

Kerr, R.J., Tier, B., McRae, T.A., Powell, M.B., Pilbeam, D.J., Dutkowski, G.W. and Apiolaza, L.A. (2002). TREEPLAN® User Manual Version 1. Confidential STBA Technical Report (TR02-09).

McRae, T.A., Apiolaza, L.A., Dutkowski, G.W., Kerr, R.J., Pilbeam, D.J., Powell, M.B. and Tier, B. (2003). TREEPLAN® - A genetic evaluation system for forest trees. In Proc. 27th Biennial Southern Forest Tree Improvement Conference Stillwater, Oklahoma, USA 24-27 June 2003.

McRae, T.A. (2004). Growing trees with the best genetics. In Proc. Australian Forest Growers Biennial Conference, May 2004, Ballarat, Australia. pp. 68-72.

McRae, T.A., Dutkowski, G.W., Pilbeam, D.J., Powell, M.B. and Tier, B. (2004). Genetic evaluation using the TREEPLAN® system. In: Proceedings of IUFRO Conference 'Forest Genetics and Tree Breeding in the Age of Genomics: Progress and Future' Charleston South Carolina 1-5 November 2004.