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Priorities for investment in sown pastures for the beef industry of northern Australia

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Abstract

This report was commissioned to provide an overview of past and current RD&E investment in sown pastures; its uptake by, and impact on, the northern beef industry; an analysis of gaps in knowledge, technology and management systems; a range of possible opportunities for sown pasture RD&E for northern Australia; and recommendations for sown pasture RD&E. About 53% (9-12 million ha) of the realistic potential for sown pastures, in terms of area sown, has been achieved for northern Australia. It is likely that 70% or so of this area is grass-only pasture, with buffel grass being the major species. A number of tropical legume species have been successful with leucaena and several of the Stylosanthes genus being the most widespread. However, the investment in evaluating new species has diminished greatly over the last 10-15 years for a number of reasons and this has seriously reduced research capacity in sown pasture agronomy. There is a case to be made for maintaining some capacity for plant evaluation work but it would be difficult to cost-effectively restore and sustain this capacity. Rather, it is recommended that future research should focus on sown pasture management systems with most, if not all, effort targeted at improving the productivity of the huge areas of grass-only pastures in central and southern Queensland.

Executive summary

This report was prepared to help guide future R&D investment in sown pastures for the beef industry of northern Australia (Queensland, NT, and northern rangelands of WA). Pastures containing exotic species of grasses and/or legumes have become an intrinsic part of the beef industry, especially in southern and central Queensland, and contribute around 25-30% of northern Australia's carrying capacity.

The report provides:

- An overview of past and current RD&E investment in sown pastures and its uptake by, and impact on, the northern beef industry.
- An analysis of gaps in knowledge, technology and management systems.
- A range of possible opportunities for sown pasture RD&E for northern Australia.
- Recommendations for sown pasture RD&E.

In northern Australia, two dominant approaches to pasture improvement evolved: grass pasture on the more fertile soils (especially where there was little existing native pasture) and legume-based pasture (often sown into the existing native pasture) elsewhere. The brigalow region of Queensland is the most impressive example of the impact of grass-only pasture with the Brigalow Development Scheme (1962-1968) seeing 4.5 million ha of brigalow scrub country cleared and sown to buffel and other grasses. The search for adapted tropical forage legumes commenced in earnest during the 1950s and, by 1990, over 7,000 accessions from more than 25 genera had been introduced into Australia, largely from central and South America but also from Asia and east Africa. Only a relatively small number (<10-12) of the >70 legume cultivars that have been officially released by government agencies are considered to have made a noteworthy impact on the pastoral industry.

The current area of sown pasture in northern Australia is estimated to be around 7.0 M ha. If one includes the 5 M ha of naturalised pasture, about 53% of the realistic potential for sown pastures, in terms of area sown, has been achieved. It is likely that 70% or so of the sown pasture area is grass-only pasture, with buffel grass being the major species. A number of tropical legume species have been successful with leucaena and several of the Stylosanthes genus being the most widespread.

A 1995 estimate of the net present value of introduced pasture plants to beef production was $712 million, representing a return on research investment of 6.5%. However, the investment in evaluating new species has diminished greatly over the last 10-15 years, primarily due to perceptions of sharply diminishing returns from additional research effort and to the higher priority given to grazing and pasture management for sustaining the industry's natural resources.

There is a case to be made for maintaining some capacity for plant evaluation work, especially for:

1. Responding in a timely fashion to emerging disease and pest threats to critical pasture species (including buffel grass, Rhodes grass, stylos, leucaena); and
2. Identifying candidate legume cultivars that fill any gaps in the suite of legumes available to improve productivity of the grass pastures of central and southern Queensland.

However, there is insufficient capacity remaining within either DEEDI or CSIRO to sustain an effective effort and, arguably, insufficient justification to restore capacity. Lack of justification is primarily related to the improbability of more effort in plant evaluation finding new legumes that would be any better adapted or productive than those currently available.

Further, if additional plant evaluation work were to be done, all stakeholders would need to ensure there is a robust assessment of the environmental weed risk for any candidate cultivar prior to its field evaluation, and that the evaluation process as a whole adopts a risk management approach. This would be absolutely critical if any new work involved cultivars from genera that have not been a prior source of useful pasture plants in Australia.

The report's recommendations are based on taking a targeted approach to any future work on pasture improvement – with the vast majority of any investment being targeted at improving the productivity of the huge areas of grass-only pastures in central and southern Queensland, most commonly associated with the brigalow and softwood scrub country types. The recommendations for consideration by MLA and its partners include:

- Identity and evaluate needs for additional research on the establishment, management and productivity of the available suite of legume species for improving productivity of grass-only pastures of central and southern Queensland.
- Investigate whether there are issues with availability of affordable and good-quality seed for any of the key grass or legume cultivars.
- Ensure the new project, 'High-output forage systems for meeting beef markets', identifies information gaps or other constraints to more profitable integration of sown pastures into whole-property feeding systems.
- Review the adequacy of existing databases and publications and, where justified, commission updated or new publications.

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1 Introduction and objectives

This report was prepared to help guide future R&D investment in sown pastures for the beef industry of northern Australia (Queensland, NT, and northern rangelands of WA). Pastures containing exotic species of grasses and/or legumes have become an intrinsic part of the beef industry, especially in southern and central Queensland, and contribute around 25-30% of northern Australia's carrying capacity. Add to this the fact that they also produce the highest levels of production per head, and their critical role for the beef industry in northern Australia is clear.

This report will provide:

- An overview of past and current RD&E investment in sown pastures and its uptake by, and impact on, the northern beef industry.
- An analysis of gaps in knowledge, technology and management systems.
- A range of possible opportunities for sown pasture RD&E for northern Australia.
- Recommendations for sown pasture RD&E and an investment approach.

2 Overview of past and current RD&E

2.1 History of improved pasture use

The earliest pasture development in northern Australia was associated with dairy farming, with the dairy industry in Queensland growing from around 5,000 cows in 1890 to more than 500,000 cows in the 1940s (Henzell 2007). Dairying was initially restricted to alluvial soils of the coastal river valleys and to red soil plateaus (with felling of the rainforest and/or scrub), and pastures were based on either paspalum in wetter districts or Rhodes grass in drier areas. The industry gradually spread into drier areas such as the Darling Downs. After World War 1, the frontier for dairying shifted north to the brigalow and softwood scrub soils of the Burnett and Callide valleys.

The productivity of these grass pastures was initially high but, with progressive decline in soil-available nitrogen, their quality and vigour declined and pastures were often invaded by mat grass and other weedy species. Continuing to develop new country provided one way of maintaining production. Apart from limited use of white clover and lucerne on coastal creek flats, there were few pasture legumes available until the 1960s. With the decline in the dairy industry in many districts after the 1940s, these areas were increasingly used for beef cattle - by 1990, dairy cow numbers in Queensland had declined to 1/5th of their 1940s' peak.

Expansion of the beef cattle industry across northern Australia relied on the grazing of native pasture including open woodlands, savannas and grasslands. While it was recognised that productivity varied greatly across land types and regions, there was little collection of animal production data until the 1930s. The earliest data showed that steers on black speargrass country near Gladstone gained up to 1.5-3 times as much weight a year as they did on monsoon tallgrass pastures at Katherine, and were ready for slaughter at 3-4 years of age. The degree and annual duration of nutritional constraints to cattle productivity from native pastures varied significantly with land type (fertility) and climate (length of growing season).

There appeared little that could be done to overcome these nutritional constraints apart from managing stocking rate. Tree clearing improved pasture growth and carrying capacity but without much effect on feed quality while mineral supplements solved some specific problems, such as P deficiency. It was commonly held that it was the native grasses, rather than the environment as a whole, that constrained animal production. This led to the so-called replacement approach to pasture improvement, where the intent was to sow ‘improved’ grasses like Rhodes and/or green panic, with or without a legume, to replace the existing native pasture, especially in areas with > 600 mm average annual rainfall. While this poor regard for native grasses remained for many years, the push for replacement of native pasture was tempered by the poor persistence of exotic grasses on most soils and the expense of converting large areas of native pasture.

In northern Australia, two dominant approaches to pasture improvement gradually evolved: grass pasture on the more fertile soils (especially where there was little existing native pasture) and legume-based pasture elsewhere (Henzell 2007).

The brigalow region of Queensland is the most impressive example of the impact of grass-only pasture (Anderson et al. 1984). Under the Brigalow Development Scheme (1962-1968), 4.5 million ha of brigalow scrub country were cleared with much of this sown to buffel and other grasses, mainly Rhodes and green panic, providing pastures that could carry an animal to 2.0 ha with annual liveweight gains of 160-240 kg/head. The high levels of productivity have gradually declined somewhat due to rundown in soil-available N, but these pastures are still relatively productive and remain the basis of beef cattle production in much of central and southern Queensland. Many of these pastures have remained grass-only due to issues with establishment and persistence of legumes on the heavy textured soils.

CSIRO led the first research into forage legumes for grazing, motivated in part by the opportunity to mimic the success of the ‘pasture revolution’ of southern Australia based on subclover and superphosphate (eg, Boyle 1957). The attraction of legumes was understandable given their potential to cost-effectively address the problems of a) the inherently low N status of most tropical soils and b) the annual protein drought during the non-growing season (the ‘dry season’ of the tropical savannas).

Initially the intent was to replace native pasture with exotic grasses and legumes but this approach mellowed into one based on addition of legumes to native pasture (sometimes referred to as the ‘augmentation’ approach; Miller and Stockwell 1991) – this may have been influenced by observations of Townsville stylo (an ‘accidental’ introduction to Australia) colonising native pastures of north-east and central Queensland during the 1960s (eg, Torssell 1973).

The search for adapted tropical forage legumes commenced in earnest after 1950 and, by 1990, over 7,000 accessions from more than 25 genera had been introduced into Australia, largely from central and South America but also from Asia and east Africa (Shelton et al. 2005). (Note that seed of these plant accessions is held in the Australian Tropical Crops and Forages Collection at Biloela, which is currently under threat of closure). In hindsight, the initial predictions of the impact of tropical legumes on the northern beef industry were somewhat optimistic but there is little doubt of the positive impacts of several species including cultivars of Stylosanthes and Leucaena. However, only a relatively small number (<10) of the >70 legume cultivars that have been officially released by government agencies since 1910 are considered to have made a noteworthy impact on the pastoral industry (Shelton et al. 2005).

2.2 History of R&D investment and impact

Initial estimates of the potential area for introduced sown species were relatively high, being around 41 M ha for Queensland and 6 M ha for the rest of northern Australia. However, a more realistic estimate of potential has been put at 22.1 M ha for Queensland and 0.5 M ha for the rest (Walker at al. 1997). In 1997, best estimates suggested that about 5.1 M ha had been developed to sown pasture in northern Australia with over 95% of this in Queensland. It was also estimated sown pasture species had naturalised into a further 5 M ha. The combined area at 1997 therefore represented about 45% of the realistic potential. Assuming a net annual increase in area of sown pasture of 150,000 ha since 1997, the current area of sown pasture in NA would be around 7.0 M ha, plus the 5 M ha of naturalised pasture. This would mean that about 53% of the realistic potential for sown pastures, in terms of area sown, has been achieved.

At 1997, around 70% of the sown pasture area was estimated to be grass only, with buffel grass being the major species. There are significant areas of other grasses such as Bambatsi panic, Purple pigeon grass, Rhodes grass, creeping bluegrass and signal grass sown and lesser areas of panic, setaria, urochloa and digit grasses. Areas of improved pasture sown in more recent times may have a somewhat higher proportion represented by legume-grass pasture given the availability of better adapted legumes and the increasing emphasis on ley pastures. The main legumes sown are shrubby stylo (Seca and Siran), Caribbean stylo (Verano and Amiga), leucaena and butterfly pea, with smaller areas planted to the jointvetches, burgundy bean, Siratro and other stylos (FSS, common and Caatinga). Temperate legumes used in areas of southern Queensland include the annual medics, serradella, white clover and lucerne.

By 1997, 137 cultivars had been released for use in northern Australia, with 72 grasses and 65 legumes. Commercial quantities of 29 grasses and 35 legumes were available at that time (Walker et al. 1997). In tropical pasture seed catalogues available in early 2010, up to 35 grass cultivars and 29 legume cultivars are listed.

The Beef cattle industry has provided significant funding support for improved pasture R&D in northern Australia, especially during the 1960s, 70s and 80s. Even during the 1990s, over 25% of funding from the second phase of MLA's North Australia Program (1991-96) supported the evaluation of new pasture cultivars.

However, there has been significantly less funding for evaluation and development of new pasture cultivars over the last 14 years. In preparing the plan for the third phase of NAP (1996-2001), a review was undertaken of the sown pasture work including its priority relative to other on-farm R&D investments (discussed by Walker et al. 1997). It was subsequently decided to have reduced emphasis in NAP3 on the evaluation of new pasture plants and to have more resources on assessing the technical issues and commercial value of the large number of available cultivars.

The 5-year investment period following NAP3, the Northern Beef Program 2002-06, continued the trend for less investment in evaluation of pasture plants, and increasing emphasis on management of pasture (especially native pastures), property management systems and profitability, awareness and adoption, genetics, and weeds.

Plant evaluation efforts under NAP2 and NAP3 were more systematic and coordinated than previous efforts, with the Coordinated Plant Evaluation program including a number of projects including:

- Back-up legumes for stylos; and
- Legumes for clay soils.

Across these projects, more than 1500 grasses and legumes were evaluated and 20 commercial releases were made.

The Back-up legumes for stylos (BULS) project evaluated fifty-five legumes in large sward plots in 32 separate experiments from Gympie in the south up the Queensland coast to Mt Garnet in the north and Katherine and Daly Waters in the Northern Territory (Bishop and Hilder 2005). Data collected in BULS contributed to release of cultivars of jointvetch (*Aeschynomene villosa*) for use in coastal spear grass communities of Queensland, but did not lead to release of any legumes that would match the geographic range and suitability of the stylos. Several potential cultivars were not released commercially because of low palatability at some sites and absence of specific animal liveweight gain data to back up their adaptation performance.

The legumes for clay soils project evaluated the suitability of legumes for permanent and/or ley pastures on clay soils in central and southern Queensland (Clem et al, 1996) following an earlier project in the north (Clem and Hall 1994). Some 150 tropical legumes (Clem et al, 2001) and a range of medics (Conway et al, 2001) were tested in small swards and a range of commercial and elite accessions were planted at “on farm” sites. Supporting studies to provide information on establishment (Agustin et al, 1998, Brandon and Jones, 1998) nutritional and rhizobium requirements (Bahnisch el al, 1998, Brandon and Date, 1998, Brandon et al, 1998, Spiers et al 1998), management (Dalzell et al 1998, Jones and Brandon, 1998) and the grazing value (Jones et al, 2000) were also undertaken.

Data confirmed the suitability of butterfly pea and desmanthus for clay soils, and highlighted the potential for Stylosanthes seabrana (or aff scabra as it was known then) and Macroptilium bracteatum. Accessions of these were later released as Caatinga stylo (Unica and Primar) (Edye et al, 1998) and burgundy bean. Field days and discussion groups centred on these sites also demonstrated the value of these plants to farmers and helped speed the rate of adoption, especially of butterfly pea.

More recent projects in cropping/livestock systems in Africa and Australia and supported by ACIAR have shown how these legumes can improve animal growth rates (Clem, 2004) and benefit crop production (Whitbread and Clem, xxx, Hill et al, 2009).

Importantly BULS, legumes for clay soils, and other concurrent plant evaluation projects lead to an initiative to reduce the risk of introduced plants contributing to environmental weed problems. A new project “Managing Old (discontinued) Plant Evaluation Sites” (MOPES) has taken on the costly and difficult task of eradicating 4 legume species that have some weed potential. It has also contributed to a more formal approach to the practices and processes associated with introduction, evaluation, release and development of new forage plant cultivars. A Draft Code of Practice for evaluation of future introduced forage plant cultivars has been developed (Kendrick Cox and Bruce Cook, pers comm.).

A 1995 estimate of the net present value of introduced pasture plants to beef production was $712 million, representing a return on research investment of 6.5% (Walker et al. 1997). A more recent analysis of the specific R&D investment on sown pastures has not been made. Chudleigh (2008) evaluated the economic impact of the MLA Northern Beef RD&E investment for the period 2000/2001 to 2007/08, and estimated the benefit cost ratio to be 4.2 to 1, with an internal rate of return over 27% per annum. The specific investment on improved pasture over this period was modest and focussed on increasing the adoption and successful use of pasture plants, especially stylos and leucaena.

2.3 Current R&D on evaluation and use of improved pastures

The current MLA investments in this work include:

- Presence, impact and retention of Synergistes jonesii in ‘problem’ herds grazing leucaena
- Productivity of leucaena on the Darling Downs
- High-output forage systems for meeting beef markets
- Pre-emptive eradication of weedy tropical forages (the third phase of MOPES referred to above)

Other relevant investments in R&D include:

- Pastures Australia (primarily for temperate production systems)
- Ley pasture R&D in southern and central Qld (GRDC farming systems projects; primarily to help address soil fertility decline under continuous cropping)
- Work by the Seed Technology Unit at Walkamin R. S. including:
    - summer-active forages for southern beef grazing areas;
    - fast-tracking of elite international varieties of grasses and legumes;
    - high quality hay legumes for NQ (with JCU);
    - new varieties of Desmanthus for use in north Queensland (with JCU).

The most significant activity in plant evaluation in recent years has been associated with ley pasture work in southern and central Queensland supported by GRDC and Grain & Graze. This work has been able to use the broad understanding of the adaptation of pasture grass and legume cultivars developed over previous decades of R&D (see Lloyd et al. 2007). An extension package, LeyGrain (Lloyd et al. 2009), provides the latest information on integrating pastures into cropping systems.

3 Gaps in current knowledge, technology and management systems

Walker et al. (1997) assessed the level of sown pasture technology for the major agro-ecological zones (Table 1). In terms of availability of grass and legume cultivars, all zones with average annual rainfall greater than 600mm were rated as modest (2 stars) or better. Arguably, the brigalow/gidgee zone (at least in central Queensland) can now be rated as high (3 stars) for legume cultivars, given the progress over the last 10 years with adoption of leucaena, use of Butterfly pea in ley pastures, and the potential impacts of Caatinga stylo, Desmanthus, and shrubby stylos on lighter soils. There has been less improvement in availability of persistent legume cultivars for southern areas of both the Brigalow/Gidgee and black speargrass zones, likely reflecting the marginal suitability of these areas for both tropical and temperate legume species.

Advances in the management, integration, productivity, and profitability of sown pastures are more difficult to assess, especially when most progress has no doubt been forged by producers via innovation and ‘learning by doing’ – and these learnings have not been well documented. A new project, ‘High-output forage systems for meeting beef markets’ should help capture the knowledge and experience of producers and their advisers in central and southern Queensland, but there arguably needs to be more systematic, widespread and persistent effort to foster and monitor the evolution of production systems and to evaluate their impact.

Table 1 Assessment of level of available sown pasture technology for the major agro-ecological zones[1].

Agro-ecological zones	Grass cultivars	Legume cultivars	Management	Beef production	Integrated management systems	Economic viability
Tropical tallgrass	****	***	**	***	**	**
Northern speargrass	***	****	**	****	*	*
Southern speargrass	***	**	**	***	*	*
Brigalow/Gidgee	****	**	**	***	**	****
Bluegrass on clays	****	***	**	***	**	**
Aristida/Bothriochloa	**	**	**	**	*	*
Mitchell grass	*	0	**	0	*	*
Spinifex	*	0	*	*	*	0
Mulga	*	0	**	0	*	*

[1]Available technology rated from absent (0) to very high (****).

Clements (1996) and Walker et al. (1997) identified a number of issues affecting the use and productivity of sown pastures, including:

- Availability of well adapted legumes
- Pasture and forage legumes for cropping systems
- Environmental impacts including weediness and the soil acidification risk from pasture legumes
- Pests and diseases, including the risk to stylos from anthracnose and psyllid impacts on leucaena
- Establishment risk
- Improved stability and management of sown pastures including the effects of grazing management and fertiliser
- Pasture rundown
- Integration into beef production systems
- Better provision of information to producers

3.1 Availability of well adapted legumes

Despite widespread evaluation efforts, by the mid-1990s there were few legumes known to be well adapted to the subhumid tropics and to clay soils generally (see Clements 1996). As indicated earlier, this situation has improved somewhat, at least for clay soils in central Queensland.

Clements (1996) also indicated a lack of species suited to heavy grazing, but one hopes we have moved on from accommodating poor grazing management species.

There is a general view that ‘backup’ species and/or candidate varieties be available (and that one retains the capacity to identify these) to meet the continuing challenges of pests and diseases (Hopkinson and Miller 2000; Shelton et al. 2005). Shelton et al. also indicated the desirability of being able to access new accessions for niche environments. Hopkinson and Miller (2000) bemoaned the loss of systematic plant introduction and evaluation, and the consequent halt to production of new cultivars, driven by the reduction in overall R&D resources combined with changing priorities. Their greatest fear was the risk of pests and diseases affecting one or more of the widely-used exotic pasture plants.

Another argument for on-going investment in plant introduction and evaluation is that the pay-off sometimes does not eventuate until circumstances change – for example, the success of *Clitoria ternatea* cv. Milgarra as a ley legume to restore nitrogen fertility in cropping lands in central Queensland occurred many years after it was first evaluated (see Hall 1985; Conway 2005).

One of the reasons for the reduced investment in plant introduction and evaluation was the belief that further investment will be a case of sharply diminishing returns – most promising genera have already been looked at to some extent and, arguably, there seems little chance of finding a species that adds significant value to the available suite of pasture plants. Results from the NAP 2 and 3 investments tend to support this view, with useful data on species that were already released or were at an advanced stage of evaluation, but few if any new ‘finds’ for the beef industry of northern Australia.

Plant introduction and evaluation is a resource-hungry process - the systematic screening of introduced legume species in northern Australia is primarily empirical in nature, relatively costly, and has a slow rate of progress (Clements 1996). In the absence of any reliable and robust method for predicting adaptation (or any of the other necessary characteristics), the empirical approach remains. While there have been improvements to the process, it is still a matter of testing and observation.

3.2 Pasture and forage legumes for cropping systems

Walker and Weston (1990) anticipated the growing demand for pasture legumes to help address fertility decline on old cropping soils. Lucerne and medics have filled this niche to some extent in southern Queensland while more recent work in both central and southern Queensland, supported by GRDC, has demonstrated the value of pasture phases based on butterfly pea, lablab, Burgundy bean and other species for beef production and improvement in crop yield and protein (Pengelly and Conway 2000; Whitbread et al. 2005; Lloyd et al. 2007).

It is important to note that this work was underpinned by the knowledge derived from the previous 40 years of plant introduction and evaluation.

Some information and practice gaps still remain, including: availability of high quality and less competitive grasses for ley pastures; improved integration of pasture establishment with other farming operations to minimise the time that paddocks have low ground cover; weed and disease management; and strategies that optimise value to both beef and crop production. Much of this is in the context of rejuvenating tired cropping soils but increased use of ley pastures will also have an impact on local turn-off rates for cattle.

3.3 Environmental impacts including weediness and the soil acidification risk from use of pasture legumes

The ability to maintain a significant contribution to the pasture sward over a number of years is a prerequisite for any successful pasture plant, and the mechanism for doing this will typically be a combination of perenniality and recruitment of new plants from seed. A successful pasture plant will therefore have some characteristics of a weed including the ability to colonise gaps in the pasture. So, apart from the fact that pasture plants are reasonably palatable (and therefore unlikely to grow 'out of control' under grazing), the distinction between a successful pasture plant and a potential weed is not clear-cut.

Plants that are both unpalatable and persistent are clearly a potential weed of all environments. However, there is probably no such thing as a potentially useful pasture plant that does not represent some weed risk to environments where grazing is not the only land use. On this basis, some have argued for a more rigorous assessment process before an exotic plant species is released into the Australian environment as a pasture plant, including both recognition that a successful introduction is almost certain to become a weed in some situations and an assessment of the net national benefit of the proposed introduction (eg, Lonsdale 1994). Others have also argued for restricted use of commercially-available species in pastoral areas considered to be relatively pristine in terms of vegetation condition.

Stringent border quarantine procedures introduced in 1997 ensure few, if any, high weed risk species are now imported into the country. However, there are no protocols for assessing and managing weed risk once a plant species is in the country. Following problems with previous approaches to plant evaluation, including inadequate screening of species and other aspects of risk management, a Code of Practice for evaluation of introduced forage plant cultivars for northern Australia was developed (Kendrick Cox pers comm). Its adoption and implementation by relevant appropriate State government departments are under discussion.

Stone et al. (2008) also describe an environmental weed risk assessment (EWRA) model specifically aimed at assessing the weed potential of exotic and native forage species. The EWRA model predicts and ranks species for weed risk by assessing invasiveness, impacts and potential distribution. Assessments are based on published evidence, experimental observations and intuitive responses from experienced pasture researchers, in collaboration with weed experts. Such a model should meet the need for improved environmental weed risk management in forage improvement programs.

The soil acidification risk appears to be well understood, with significant problems only likely with seed production areas in some environments. The risk is managed by avoiding pastures becoming legume-dominant especially on poorly buffered soils (Noble et al. 2000). Legume areas on light-textured soils used for regular hay making are probably at greatest risk as repeated removal of dry mater from the paddock reduces organic matter input to the soil.

3.4 Pests and diseases, including the risk to stylos from anthracnose and psyllid impacts on leucaena

Resistance to anthracnose is considered the key objective for any work with stylos, be it evaluation of new lines or improvement of existing lines (eg, by selection or genetic modification) (Clements 1996). According to Walker et al. (1997) the most immediate issue is to assess the risk of current stylo cultivars and new germplasm from the wide range of South American races of anthracnose.

It appears that nearly all the recent research effort related to stylos and anthracnose has occurred outside of Australia although often with the involvement of Australian researchers and building on earlier research done within northern Australia often with industry funding. The most significant report comes from the recent ACIAR project, 'High-yielding anthracnose-resistant Stylosanthes for agricultural systems in India and China' (Chakraborty 2004).

According to this report, Stylosanthes anthracnose has become one of the best-studied diseases of pasture and forage plants, mainly as a result of a sustained effort by a team of international researchers. The genetic structure, virulence profile and evolution of the pathogen population have been characterised; understanding of anthracnose epidemiology improved; and anthracnose-resistant and high-yielding cultivars developed and shared between countries by virtue of a free and open germplasm exchange program. Improved understanding of the pathogen population has meant that countries can now assess the risks from exotic races and take steps to minimise their accidental introduction. However, Australian linkages to this work appear to have dropped away in recent years due to lack of funding on anthracnose.

The question for northern Australia relates to the capacity to respond to a breakdown in resistance to anthracnose of, say, Seca stylo. This is likely a low priority for any immediate action. A problem of this nature has not emerge in the last 15 years and, if a problem did emerge, there is likely to be capacity overseas (eg, South America) to help address it.

The current MLA-supported work on developing a psyllid-resistant variety of leucaena, and the earlier work on rust-resistance for forage oats, are examples of responding to issues as they emerge. This is possible as long as the capacity to respond exists and can be made available.

3.5 Establishment risk

According to Clements (1996), the risk and costs of pasture establishment are often perceived to be a major issue. However, he contends that pasture establishment is a mature technology, and that only marginal gains will accrue from further research on the operational aspects of establishment. Despite this, establishment failure and poor establishment continue to be a major issue and cost to the industry and individual farmers. Seed quality and understanding the processes for successful establishment are the key factors (Bob Clem, per comm.). One area that may also require ongoing attention is the survival of root-nodule bacteria associated with inoculated legume seeds, given the specific requirements of a number of important legume cultivars.

A related issue is the availability of affordable high-quality seed for pasture plants. There is anecdotal evidence that seed of several cultivars is in very limited supply and this is constraining their contribution to improved beef production.

One of the key issues related to the cost and reliability of establishment is the uncertainty about the coated seed technology, and how to ensure a producer gets seed that will give the best possible result.

3.6 Improved stability and management of sown pastures including the effects of grazing management and fertiliser

There is little doubt that most evaluation of pasture plants, especially legumes, has been focussed on adaptability. There has been an implicit assumption that legume cultivars would combine with other pasture species, often native ones, to produce a pasture of where grass and legume components could co-exist and persist (albeit with variation in the mix of grass and legume over time). In retrospect this appears to be naïve, at best, especially given the additional complications of mixed land types (and associated variation in soil fertility), variations in imposed grazing pressure, and the consequences of selective grazing.

So, in line with the views of Walker et al. (1997), one must question the expectation that persistent sown pastures, or native pastures oversown with legumes, can be developed and maintained over long periods of 20 or more years with few management inputs. However, the degree and extent of problems with the condition and stability of sown pastures is not at all well documented. This makes it difficult to identify and prioritise specific research issues. In addition, some degree of instability in pasture composition is inevitable due to seasonal fluctuations and changes in soil available N over time.

The ‘stability’ of sown and oversown pastures emerged as an issue quite early in the use of improved pastures. Early examples included the change in mixed grass pastures (eg, buffel, Rhodes, green panic) to buffel dominance in drier environments or after drought, and the spread of Townsville stylo into native pastures of north-east Queensland to the disadvantage of perennial grasses (and varying with soil fertility and grazing pressure). When anthracnose caused a sharp decline in Townsville stylo from most areas during the early 1970s, the land was often left with a limited coverage of annual grasses and weeds. The shrubby stylos such as Seca can outcompete native grasses, especially as the latter are preferred by cattle early in the growing season when they are most vulnerable to defoliation. Consequently, achieving a balance of stylo and grass requires planned management of grazing and fire (Cooksley 2000).

Persistence of some legumes is dependent on adequate soil fertility (especially P) and sympathetic grazing management. Apart from the need for moderate soil fertility, and later problems with disease, siratro was considered to be too sensitive to grazing (viz, continuous stocking at moderate to heavy rates). Given the growing awareness and understanding of planned grazing management, especially the control of stocking rate and the use of wet season spelling, one wonders if siratro and other twining species of legume would not be more of a success in today’s industry.

3.7 Pasture rundown

Rundown is commonly used to describe the decline in productivity that occurs in tropical and subtropical sown grass pastures as they age. This decline in productivity has been shown to be caused by reductions in the amount of available soil nitrogen (N) that the pasture plants can take up (but not by a decline in total soil nitrogen as that usually remains remarkably stable). The implications of sown pasture rundown are very important, especially for properties in central and southern Queensland which rely heavily on buffel grass pastures for growing and finishing stock. Given that central and southern Queensland support almost half of Queensland’s cattle, much of this on sown grass pasture, the broader industry implications are also very important.

Assuming 65% of the sown pasture area is grass-only pasture, that there is about 12 M ha of sown pasture in northern Australia, that the average stocking rate is 1 AE to 2.5 ha, that the pasture is used mainly for growing animals and they have an average annual LWG is 140 kg, and that having an effective legume component would add at least 35 kg per head per year, the impact of future pasture improvement could be up to an additional 109,000 tonne of beef. As northern Australia produces about 1.1 M tonne of beef a year (primarily from Queensland), this represents a potential 10% increase in production.

Targeting any future systematic investment in sown pastures almost exclusively on areas of grass-only sown pasture in Queensland clearly offers the greatest benefits, relative to other options such as finding additional legumes for extensive native pastures.

3.8 Integration into beef production systems

According to Walker et al (1997), there was inadequate information on (1) how best to integrate sown pastures into whole-property feeding systems and (2) the economics of sown pasture use in a whole-property context.

There is little evidence that these gaps have been filled. It appears that the reduced investment in plant evaluation was not matched by specific investments in integration and economics. It is likely that some relevant work was done within BeefPlan and other broad-based project work but this is not well documented. Obviously, sown pastures have continued to feature in the extension efforts of State Departments and other providers. However, apart from work associated with ley pastures and initiatives undertaken by groups like the Leucaena Network, sown pastures issues and opportunities have declined in prominence.

In any case, progress in the understanding and practice of integrating sown pastures and/or economic impacts is not well documented, making specific issues and priorities difficult to identify.

3.9 Better provision of information to producers

The reduction in funding for plant evaluation coincided with increased emphasis within CSIRO and State Departments on natural resource management, especially on the ecology and management of native pastures. There seems little doubt the pendulum swung somewhat too far, with the result that there are far fewer research and extension professionals with experience in sown pastures.

Consolidating the information base and making it available to researchers, extension officers, other service providers and producers has therefore received significant attention over the last decade or so. Examples include:

- Pengelly et al. (2005) accessed information on the adaptation and use of >200 forages (from peer reviewed literature, research reports and the memories of experienced forage agronomists) and, from this, developed the Selection of Forages for the Tropics (SoFT) database (both CD version and on the web - http://www.tropicalforages.info/). The primary audience for this database is those providing advice to smaller-scale farmers in developing countries of the tropics.
- The Tropical Grassland Society developed the web-based ‘Pasture Picker’ (http://www.tropicalgrasslands.asn.au/pastures/pasturepicker.htm), with emphasis on the suitability of species for tropical and subtropical Australia. Ian Partridge of QPIF has been updating the data base as needed but its on-going resourcing is uncertain.
- ‘Pasture legumes for subtropical grain and pastoral systems: the ute guide’ (2007): This 'ute guide' is designed to be used to help farmers and advisers identify and select the most

appropriate range of pasture legume species and cultivars for the cropping and pastoral zone in northern Australia, a zone defined as being between Clermont in Central Queensland in the north, and Gilgandra in central NSW in the south. It was resourced by AWI and GRDC with input on the more tropical species from DPI&F.

- Leucaena: a guide to establishment and management (2006) – this MLA booklet combines the experiences of many producers with findings from research especially in relation to successful establishment and subsequent management.
- Pastures: Mackay Whitsunday region - a guide for developing productive and sustainable pasture-fed grazing systems (2007) by Harry Bishop, QDPI.
- LeyGrain (Johnson et al. 2006), provides the latest information on integrating pastures into cropping systems.
- Far North Queensland – Grass-fed Beef Production (2008). Module 3. Pasture systems. QDPI.
- Sown pasture modules within each regional version of the EDGE Grazing Land Management workshop.

There may well be a case for updating older publications that underpin much of the extension work, including:

- The Buffel Book (a guide to buffel grass development in Queensland), Queensland Department of Primary Industries (1991).
- Sown pastures for the seasonally dry tropics - Queensland Department of Primary Industries (1993)
- Sown pastures for the brigalow lands - Queensland Department of Primary Industries (1993)
- Stylos for better beef - Queensland Department of Primary Industries (1995)

4 Conclusions and recommendations

There is a case to be made for maintaining some capacity for plant evaluation work, especially for:

1. Responding in a timely fashion to emerging disease and pest threats to critical pasture species (including buffel grass, Rhodes grass, stylos, leucaena); and
2. Identifying candidate legume cultivars that fill any gaps in the suite of legumes available to improve productivity of the grass pastures of central and southern Queensland.

However, there is insufficient capacity remaining within either DEEDI or CSIRO to sustain an effective effort and, arguably, insufficient justification to restore capacity. Lack of justification is primarily related to the improbability of more effort in plant evaluation finding new legumes that would be any better adapted or productive than those currently available.

Further, if additional plant evaluation work were to be done, all stakeholders would need to ensure there is a robust assessment of the environmental weed risk for any candidate cultivar prior to its field evaluation, and that the evaluation process as a whole adopts a risk management approach. This would be absolutely critical if any new work involved cultivars from genera that have not been a prior source of useful pasture plants in Australia.

The following recommendations are based on taking a targeted approach to any future work on pasture improvement – with the vast majority of any investment being targeted at improving the productivity of the huge areas of grass-only pastures in central and southern Queensland, most commonly associated with the brigalow and softwood scrub country types. The recommendations for consideration by MLA and its partners include:

- Identity and evaluate needs for additional research on the establishment, management and productivity of the available suite of legumes species for improving productivity of grass-only pastures of central and southern Queensland. Two specific issues are:
    - Plants that have yet to reach their potential impact, such as Desmanthus and S. seabrana.
    - Uncertainties about coated seed technology and how to ensure producers acquire seed that will give the best possible result.
- Investigate whether there are issues with availability of affordable and good-quality seed for any of the key grass or legume cultivars. This would require discussions with representatives from the seed technology unit at Walkamin R. S. and from seed companies.
- Ensure the new project, 'High-output forage systems for meeting beef markets', identifies information gaps or other constraints to more profitable integration of sown pastures into whole-property feeding systems.
- Review the adequacy of existing databases and publications and, where justified, commission updated or new publications.

There may also be merit in making an open call for projects related to key issues to ensure we capture ideas that may otherwise be missed in simply commissioning work on the above topics. For example, proposals could be called in relation to:

- Improving efficiency and effectiveness of establishment of pasture plants in the sown pasture areas of central and southern Queensland

Technologies which improve the productivity and resilience of grass-only grass pastures in central and southern Queensland.

5 Success in achieving objectives

The objectives have been met although more up to date statistics on areas and condition of sown pastures across northern Australia would have been useful. However, updated statistics would not influence the recommendations.

6 Impact on meat and livestock industry – now & in five years time

Increased investment in sown pasture R&D that targets the sown grass pastures of central and southern Queensland could lead to cost-effective increases in total beef production from northern Australia of up to 10%. This will likely accrue over a 10-year period from the start of the additional investment in research and extension.

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