The role of native grasses and legumes for land revegetation in central and eastern Australia with particular reference to low rainfall areas

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Abstract

There is increasing interest in using native grasses and legumes in revegetation programs directed at pastoral, amenity and mining use. However, few native grasses and essentially no native legumes are available commercially. The developing Native Seed Industry is based largely on the use of locally harvested seed from wild stands, a situation likely to continue at least in the short to medium term, although improved cultivars being developed in a number of domestication programs are now reaching the early stage of commercialisation. The major factor limiting further expansion in the area sown to native grasses in Australia is the current fragmented state of the industry which is characterised by fickle demand for the often low and irregular seed supplies of variable quality. Six cultivars of 3 native grass species and 1 native legume have been granted Australian Plant Breeders Rights (PBR), but limited quantities of seed are available commercially.

However, in low rainfall environments (<600 mm annual rainfall), the general failure of exotic species to persist has re-focused attention towards the use of low-input native species which have ecological and adaptive advantages (Wilson 1996).

In this paper, we consider the benefits of native grass and legume species, discuss their evaluation and development, and describe those which are commercially available.

Advantages of using native species

Australia’s native grasses and legumes have evolved mainly on soils of low fertility, with climatic conditions characterised by highly variable and generally low annual rainfall. Since they have evolved under these often harsh climatic and edaphic conditions, Australian native grasses and legumes are better adapted than most exotic species, which tend to have evolved under more benign environments.

Apart from these adaptive advantages, native species have been recognised for their low requirements compared with exotic species in...
Native grasses and legumes for revegetation

terms of nutrients and establishment costs (Wilson 1996). More recently, the ecological benefits of using native species have been recognised increasingly by the Australian public. Native herbaceous species contribute to maintaining ecological integrity and biodiversity and provide suitable habitats for indigenous flora and fauna. Combined with this emphasis on the re-establishment and/or maintenance of natural diversity has been an acknowledgement that the use of exotic species provides a potential threat of introducing weeds (Humphries et al. 1991). Potential threats in environmentally sensitive areas are posed by widely used species such as buffel grass (Cenchrus ciliaris), currently being used in revegetation programs in rangeland areas of central Australia. Here, they tend to dominate the vegetation, in some cases resulting in the loss of the native grass population (Reu 1995a). On mined land undergoing rehabilitation, rill erosion can continue between the grass tussocks to the detriment of landscape stability.

The failure of most introduced species to persist under the variable climatic conditions in arid Australia has recently stimulated interest in the use of native species in revegetation programs. In Queensland alone, almost 500 accessions of exotic species have been evaluated for the arid region (Johnston 1990), but few were identified as “useful”, especially in terms of their ability to withstand dry periods. This has provided an incentive for government agencies to examine the potential use of native species in low rainfall areas.

Disadvantages of using native species

Past emphasis on the evaluation of exotic species for revegetation programs has been based largely on their value for livestock production and ease of seed production. While native species may provide forage sustainably, generally they produce lower fodder quality and yields than exotics (Wilson 1996). The use of natives in revegetation programs has therefore focused on agricultural land of lower productivity or on non-agricultural land (e.g., roadsides, mine sites).

Native grasses and legumes also generally have poor establishment rates and slow initial growth rates. While the latter is an adaptation that assists in long-term survival, the reasons for low establishment rates are not always clear. Moreover, broad guidelines for successful establishment of native species are generally not practicable; the range of environmental conditions in which they are being used, the purposes for which they are being employed, and the type of species often require techniques tailored to meet site-specific requirements (Silcock and Scholz 1996).

These latter problems highlight the need to study appropriate management and establishment technologies as well as ecological aspects when developing new varieties of native species. Rather than expecting natives to be used with existing technologies developed for exotic species, we should anticipate that alternative technologies may be required. For example, the hygroscopically passive awns found in Chloris and Microlaena spp. orient the falling seeds, helping them to become embedded in the soil surface in a position advantageous to establishment, but pose seed processing and handling problems (Loch and Clark 1996). In such cases, new technologies that improve handling without detriment to establishment need to be developed to facilitate their commercial use.

Another example of the need to adapt technology to suit plant characteristics is the technique for harvesting seed. Many native grass species produce difficult-to-handle “chaffy” seeds. The development and adoption of brush harvesters has facilitated the harvesting of chaffy-seeded grasses and allows several passes to be made, picking up ripening seed each time with only minor damage to the plant (Loch et al. 1996).

The evaluation and selection of native grass and legume species for use in revegetation programs is a recent phenomenon in Australia (only within the last 12 years) and has focussed almost exclusively on grasses. Six native grass cultivars and 1 native legume have been registered under PBR. These include cultivars of Danthonia richardsonii and D. linkii, Microlaena stipoides and Glycine latifolia. Advanced selections of Astrebla lappacea and A. pectinata (Waters and Mummich 1995) have been made with commercial release expected in the near future. Details of the selection process in each of these cultivars have been described by Waters and Johnston (1996) and Lodge (1996).

Currently, a major constraint to broad-scale use of native grass and legume species in Australia is the lack of commercial quantities of appropriately priced, quality seed. This is in contrast to the situation in the USA where
approximately 100 native species are now available commercially in the state of Utah alone (R.B. Hacker, personal communication).

Natural stands (of grasses) are harvested currently for use in regional revegetation programs being undertaken throughout eastern Australia, for town beautification, green corridors, habitat maintenance, or agricultural land reclamation purposes. For these purposes, the harvesting and sowing of mixed seed from native stands may result in a more robust and biologically stable stand than a monospecific pasture (Silcock and Johnston 1993).

The Native Pasture Seed Industry, however, is still in its infancy, and is characterised by fickle demand for the often low and irregular seed supplies of variable quality (Loch et al. 1996; Waters and Noad 1996). Seed production cannot continue without markets, and markets will not continue without seed to sustain them. Until this nexus is broken, and a stronger, more reliable market developed, native species will continue to play only a minor role in revegetation programs.

Development and use of native species

The potential for developing varieties of native species is considerable. In Australia, there are more than 750 native grass species in about 180 different genera (Lodge and Groves 1990).

As new cultivars are developed, more species will be available for use, but there could be some loss in genetic diversity (as compared with natural populations). With sexually-reproducing species, it is unlikely that this will be a serious problem, as there is likely to be extensive genetic variation within the cultivar. This is not the case, however, with obligate apomicts (such as Heteropogon contortus).

Simple, inexpensive sowing and establishment techniques need to be developed for these species (Wilson 1996). Selected cultivars should be targeted for particular roles and agronomic merit (e.g. green leaf production) and evaluated against other species (native or exotic) that are being used for similar purposes. Native cultivars should not be released just because they are of native origin, but because they have merit in their own right (Garden et al. 1996).

Roles played by native species

The more important native grass species which have been evaluated for use in revegetation programs are listed in Table 1. Three native legume species should also be noted, these being Glycine latifolia, Psoralea patens (Skerman 1957) and Rhynchosia minima. Only the first of these would be rated highly for commercialisation and, although G. latifolia cv. Capella has been awarded PBR protection, its formal release is still uncertain.

Pastoral use

Selected grasses. Native grasses contribute substantially towards pasture production. In some temperate areas, native grasses contribute up to 60% or more of the pasture (Lodge and Groves 1990; Munnich et al. 1991), providing benefits such as summer and drought fodder, persistence and adaptation to low fertility soils (Leigh 1990; Garden et al. 1996). In semi-arid (Harrington et al. 1984) and tropical rangelands, native herbaceous species comprise the entire diet of grazing livestock. Most of the development of native grass species for sowing has been recent and has been concerned primarily with their development for use in the pastoral industry.

Danthonia spp. are palatable, cool season, perennial grasses which produce green forage high in crude protein (Lodge 1993). Two cultivars have been developed for use in temperate areas of eastern Australia. D. richardsonii (cv. Taranna) is adapted to a range of soil types whereas D. linkii (cv. Bunderra) prefers finer textured soils (Table 1). These were the first native grass varieties to be released, and only recently have they been sown by graziers in southern New South Wales.

Microlaena stipoides (cv. Wakefield) is a more recent release for the northern tablelands of NSW (Table 1). In this area, M. stipoides forms a valuable component of native pastures (Jones and Whalley 1994). It is tolerant of both shade and grazing.

Astrebla lappacea and A. pectinata (Mitchell grasses) are warm season perennials (Table 1). Astrebla spp. are the basis for the most productive and stable native grasslands of eastern Australia (Orr and Holmes 1984). Decline of Mitchell grass pasture has resulted from increases in areas being cropped, inappropriate
Table 1. Native species evaluated for use in revegetation programs (adapted from Loch and Clark 1996).

<table>
<thead>
<tr>
<th>Species</th>
<th>Use2</th>
<th>Problems</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astrebla elymoides&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>High percentage of trash harvested (influence stalks brittle &amp; break off with spikelets)</td>
<td>Widespread on heavy Mitchell grass plains; establishes more readily than A. pectinata</td>
</tr>
<tr>
<td>Astrebla lappacea&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>Long, often multiple seed heads can become lodged; very persistent</td>
<td>Widespread on heavy Mitchell grass plains in the subtropics</td>
</tr>
<tr>
<td>Astrebla pectinata&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>Seeds ripen over a prolonged period</td>
<td>Widespread on heavy Mitchell grass plains in more arid areas</td>
</tr>
<tr>
<td>Astrebla squarrosa&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>Handling difficult (awns &amp; bristles very prickly); high percentage of trash harvested</td>
<td>Widespread on heavy Mitchell grass plains in tropical areas; tolerates heavy grazing</td>
</tr>
<tr>
<td>Bothriochloa bladhii&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>Handling difficult (seeds cling together)</td>
<td>Widespread on loam &amp; clay soils</td>
</tr>
<tr>
<td>Bothriochloa decipiens&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>Handling difficult (seeds cling together)</td>
<td>Widespread on less fertile loam &amp; clay soils</td>
</tr>
<tr>
<td>Bothriochloa macra&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage, amenity</td>
<td>Harvestable stands isolated &amp; patchy; low drought tolerance</td>
<td>Widespread on loams &amp; clay soils in SE Australia</td>
</tr>
<tr>
<td>Chloris truncata&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>Amenity</td>
<td>Adapted to a wide range of soils in semi-arid areas; colonises denuded land</td>
</tr>
<tr>
<td>Cymbopogon ambigus&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Erosion control</td>
<td>Seed hand harvested; little known about establishment characteristics</td>
<td>Prefers wetter areas</td>
</tr>
<tr>
<td>Cymbopogon refractus&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>Low seed yields; difficult to clean</td>
<td>Promising roadside species in SE Queensland</td>
</tr>
<tr>
<td>Danthonia caespitosa&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>Needs winter/spring rain</td>
<td>Widespread in temperate Australia, from clay soils to light sandy loams; recruits readily</td>
</tr>
<tr>
<td>Danthonia linkii&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>Weed control; seed harvesting &amp; processing</td>
<td>Widespread in temperate Australia</td>
</tr>
<tr>
<td>Danthonia richardsonii&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage, amenity</td>
<td>Weed control; seed harvesting &amp; processing</td>
<td>Widespread in temperate Australia</td>
</tr>
<tr>
<td>Dichanthium sericeum&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage, amenity</td>
<td>Handling difficult (seeds cling together)</td>
<td>Widespread dominant species on alkaline clay soils</td>
</tr>
<tr>
<td>Digitaria brownii&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>Post-harvest dormancy; seedlings very moisture-sensitive</td>
<td>Variable species widespread on sands, loams &amp; hard red earths</td>
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<tr>
<td>Diplachne fusca&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Rehabilitation</td>
<td>Will persist only while conditions remain favourable</td>
<td>Salt-tolerant; occurs naturally on clay pans; establishes well on hard-setting clay soils</td>
</tr>
<tr>
<td>Elymus scaber&lt;sup&gt;1&lt;/sup&gt;</td>
<td>M Forage</td>
<td>Low seed fill in apomictic forms</td>
<td>Widespread in southern Australia</td>
</tr>
<tr>
<td>Enneapogon avenaceus&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>Rapid shedding of ripe seed; seed fill usually-low</td>
<td>Good pioneer species adapted to coarse-textured soils</td>
</tr>
<tr>
<td>Eragrostis setifolia&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>Very small seeds; quality usually low</td>
<td>Widespread in arid areas, especially on heavier soils</td>
</tr>
<tr>
<td>Eulalia aurea&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Rehabilitation</td>
<td>Low seed fill; seed retention poor; seedling survival poor</td>
<td>Widespread dominant species on sandy-clay soils</td>
</tr>
<tr>
<td>Heteropogon contortus&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>Handling difficult (seeds sharp &amp; cling together)</td>
<td>Widespread dominant species on well-drained loams &amp; clay soils</td>
</tr>
<tr>
<td>Microlaena stipoides&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Turf, amenity, forage</td>
<td>Broadacre establishment; weed control; seed harvesting and processing (isolated patches)</td>
<td>Widespread shade-tolerant species for acid soils in cooler areas</td>
</tr>
<tr>
<td>Monachather paradossa&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>Difficult to locate harvestable stands</td>
<td>Widespread on red earths &amp; sandy soils in mulga country</td>
</tr>
<tr>
<td>Panicum decompositum&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>Strong post-harvest dormancy</td>
<td>Rarely forms dominant stands; good rehabilitation species</td>
</tr>
<tr>
<td>Plectrachne, Triodia spp.&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Low seed fill</td>
<td>Low seed fill; low seed yields; plants easily damaged by wheeled traffic</td>
<td>Useful for mine rehabilitation in arid N &amp; NW Australia</td>
</tr>
<tr>
<td>Sporobolus caroli&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>Very low laboratory germination</td>
<td>Good field establishment on heavy soils; useful early coloniser for mined land</td>
</tr>
<tr>
<td>Sporobolus virginicus&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>Low seed fill</td>
<td>Dominant on saline tidal flats</td>
</tr>
<tr>
<td>Themeda triandra&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Amenity</td>
<td>Low numbers of seeds per kg</td>
<td>Widespread on well-drained sandy to clay soils</td>
</tr>
<tr>
<td>Thryidolepis michelliana&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Forage</td>
<td>Difficult to locate harvestable sized stands; readily grazed</td>
<td>Common on red earths and sandy soils in mulga country</td>
</tr>
<tr>
<td>Zygochloa paradoxa&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Rehabilitation (erosion control)</td>
<td>Seed hand harvested; little known about establishment characteristics</td>
<td>Unpalatable; highly tolerant of grazing; exists in large dense stands</td>
</tr>
</tbody>
</table>

<sup>1</sup>Current priority ratings for commercialisation: H = high, M = medium.
<sup>2</sup>Purpose for which species has mainly been evaluated.
grazing management and flooding. Cultivars of these species with a high leaf percentage have been developed for use in reseeding pastoral areas and rundown cropping paddocks in north-eastern NSW and central-western Queensland (Waters and Munnich 1995).

The LIGULE project (Low Input Grasses Useful in Limiting Environments) aims to develop and release a range of agriculturally useful perennial native grasses for the 500–700 mm rainfall zone in the Murray-Darling Basin (Johnston et al. 1995). In this region, large areas have been cleared extensively and summer-growing native plants have been replaced by exotic temperate perennial grasses which fail to persist. As a result, these areas are becoming dominated by annual plants, leading to an increase in ground water recharge, dryland salinity and soil erosion. From an original collection of 33 native grass species, 12 have been selected for further evaluation of their ability to reduce ground water recharge.

A number of other species have also been evaluated for use in the pastoral industry, some of which have undergone selection within populations. No commercial release of these species is planned, though commercial quantities of wild-collected seed are available for some of them (e.g. Dichanthium sericeum). The major ones are described below.

Twenty-two native grass species were identified for use on red soils in the semi-arid areas of eastern Australia (Torpy et al. 1994). In these areas, the desirable perennial component of the pasture has been reduced (Harrington et al. 1984), and in some cases, unpalatable woody shrub populations dominate the landscape. Few adapted exotic pasture species are available for reseeding purposes. Three perennial native species, Danthonia caespitosa, Digitaria brownii and Dichanthium sericeum (Table 1), were selected because seed could be harvested with relative ease and they proved to establish successfully in the field.

In the arid rangelands of central Australia, 12 native grass species were evaluated for their suitability in rehabilitation programs on different soil types (Reu 1995b). Selection criteria included palatability, drought tolerance, provision of ground cover in dry periods and quick growth responses following rainfall. Four species were identified as promising: Astrebla pectinata, Bothriochloa ewartiana, Diplachne fusca and Enneapogon avenaceus (Table 1).

Two species, Thyriddolepis michelliana and Monachather paradoxa (Table 1), native to the mulga lands of south-western Queensland, were identified by Johnston (1990) as suitable for reseeding these areas. Some selection between ecotypes within species has been undertaken. Selection criteria included height of inflorescence, seed yield, and high amounts of leaf production.

Selected legumes. The only native forage legume close to commercial release is Glycine latifolia cv. Capella, which has been described for Australian PBR (Jones 1994). This is a mainly subtropical species which is drought-tolerant and frost-resistant and is adapted to clay soils (Rees et al. 1993). Capella is persistent under grazing, and spreads by rooting down of the stolons or by seed.

Amenity use

In both urban and semi-rural areas, there is public demand for seed of native species to re-establish natural biodiversity and to reduce maintenance and for the ability of native grasses to “soften” the appearance of the landscape. Two such native grass cultivars have been developed — D. richardsonii cv. Hume and M. stipoides cv. Shannon. A second selection of M. stipoides (cv. Griffin) has been released as a turf variety, and cultivars of Themeda triandra and Bothriochloa macra (Lodge 1996) are expected to follow in late 1996 (Table 1).

Mine site rehabilitation

Last year in central Queensland, the mining industry used 875 kg of native shrub and tree seed, but only about 50 kg of native grass seed (Roe 1996). This industry is expected to continue to rely on the use of native tree and shrub species, which appear to have fewer seed collection and germination problems than some of the native grasses. As native grass species are not able to provide the rapid early ground cover required by this industry, exotic species are used initially as an understorey before introducing natives later on. A strip of established exotic grasses is killed with herbicide and seed of native species broadcast into the treated strips in the
hope that they will spread. Further bands may be sown at later dates. The use of native grass species is necessary, not only to enhance the species diversity of the site, but also because some exotic species tend to grow rank and fail to persist in the absence of grazing. Generally, exotic grass species also tend not to persist in the long term due to the low soil fertility and soil structural problems associated with mine site areas (P.A. Roe, personal communication).

In the past, the use of native species in the revegetation of mine sites has been driven largely by legislative requirements and, more recently, by public expectation. However, the Mining Industry is now funding its own studies of native ecosystem management (with 4 major projects in eastern Australia), as well as undertaking local seed harvesting and processing.

This involvement in the evaluation of native species has become an economic necessity as revegetation programs represent approximately 5% of the total mining costs. With an expected annual expansion of 5000 ha of disturbed land, future demand for native species from the Mining Industry is likely to increase. However, these areas are dwarfed by the extensive areas of Australia’s rangelands that have experienced a reduced abundance of perennial grasses through the effects of grazing (Harrington et al. 1979).

**Genetic resources for native species of grasses and legumes**

Almost all projects aimed at developing cultivars or gaining an understanding of genetic variation in native grasses and legumes have relied on collections made from the wild for the purpose. Conservation of the genetic resource has been almost entirely *in situ*; an example is a genetic study of *Heteropogon contortus* (Tothill and Hacker 1976). This study was based on a collection covering the entire Australian geographic range of the species, but was not conserved for future study or development. There is an urgent need for *ex situ* conservation of collections of native grasses and legumes currently under study, as a basis for further development. The Australian Tropical Forages Genetic Resource Centre (in Brisbane) has offered to provide this service.

**Conclusions**

Native grass and legume species currently play only a minor role in revegetation programs directed at pastoral, amenity and mining use in Australia. Most of this is seed harvested from wild stands, a situation likely to continue at least in the short to medium term, although improved cultivars being developed in a number of domestication programs are now reaching the early stage of commercialisation.

The major factor limiting further expansion in the area sown to native grasses in Australia is the current fragmented state of the industry, which is characterised by fickle demand for the often low and irregular seed supplies of variable quality. Until a stronger, more reliable market develops, native species will continue to play only a minor role in revegetation programs despite their advantages.

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