prospects for perennials

2009

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Prospects for profitable perennials in mixed farming systems

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PROFITABLE PERENNIALS™ FOR AUSTRALIAN LANDSCAPES

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foreword

Prospects for perennials is the fourth and final publication to come from the Future Farm Industries CRC (FFI CRC) *Prospect Statement* series. It's a definitive guide to incorporating Profitable perennials™ (new perennial pasture cultivars) into grazing and cropping systems of southern Australia. With all the challenges facing Australian agriculture, farmers need new solutions and the release of this publication is indeed well timed.

Profitable perennials™ provide new ways for farmers to increase productivity and remain profitable in a drying and uncertain climate. Coupled with this challenge is the realisation that historical approaches to farming were far from best practice and the landscape has paid the price — dryland salinity being an obvious example. History has also shown that farmers are quick to embrace research and technology development that offers profitable adaptation to new situations.

Prospects for perennials will allow farmers to assess for themselves, region by region, their potential use of perennial pasture species and cultivars way beyond their past experience in productivity and adaptability of grazing enterprises.

These Profitable perennials™ are destined to be incorporated into FFI CRC's exciting new farming systems — *EverGraze*® for specialist livestock producers and *EverCrop*® for crop-livestock production in Australia's wheatbelt.

Prospects for perennials makes more relevant the research outcomes that came from FFI CRC's predecessor, the CRC for Plant-based Management for Dryland Salinity. Perennial plants were originally seen as playing an instrumental part in mitigating the causes of dryland salinity. However, it soon became apparent during the life of the CRC that perennials could play a much greater role in agriculture to bring productivity improvements, adaptation to increasing droughts and natural resource management benefits. This discovery led to the creation of the FFI CRC.

In fact, the intent of this publication closely mirrors the purpose of FFI CRC and is one of the first steps the CRC has taken to achieve is overall goal of improving the profitability and sustainability of livestock and cropping enterprises through the use of perennials. More specifically, it has taken the research and technologies of CRC Salinity and shown that perennials are part of the solution to the big issues facing contemporary broadacre agriculture — declining terms of trade, adaptation to drought and climate change, and sustaining natural resource condition.

Through the use of regional overviews, case studies and economic analyses featured in this publication, readers can gauge for themselves how perennial plants can add value to their business while gaining a better understanding of where they best fit into their landscape. *Prospects for perennials* examines other management aspects of introducing perennials into the landscape such as weed risk. It also recognises the fact that we haven't worked out all of the answers and it highlights new technologies currently on the pathway to development and the need for ongoing research and field trials.

Prospects for perennials is more than interesting reading; it shows there is a way forward to achieve a new level of sustainability and productivity in broadacre agriculture in trying times, through the use of convincing case studies and compelling production and economic evidence. It also provides readers a glimpse of what the future may hold, through the work of FFI CRC. I believe this latest *Prospects Statement* will inspire farmers and their advisers to incorporate perennial plant-based technologies into their business planning.

Kevin Goss

Chief Executive Officer
Future Farm Industries CRC

Acknowledgements

This document is the culmination of seven years research by scientists within the former CRC for Plant-Based Management of Dryland Salinity (CRC Salinity) and their on-going work within the Future Farm Industries CRC (FFI CRC). Progress into the use of perennials in mixed farming would not have been achieved without all their work.

In particular thanks go to:

Associate Professor Mike Ewing for his help and guidance throughout the construction of this publication; and to the scientists in the CRC Salinity Sub-program 5 for making so readily available all the results from their field and laboratory trials.

Development of the regions into which this Prospects Statement *would be broken into was an interesting, if at times frustrating process. The final decision was based on the advice of the following people; Geoff Moore, Dr Clinton Revell and Associate Professor Mike Ewing (Western Australia); Dr Brian Dear, Dr Sue Boschma and Dr Guangdi Li (New South Wales); Dr Mary-Jane Rogers, Dr Zongnan Nie and Dr Janine Croser (Victoria); Andy Craig and Dr Nick Edwards (South Australia).*

Thanks must also be given to the Geographic Information Systems (GIS) scientists who put together the State Profitable perennials *regions; Dr Jean-Philippe Aurambout (Department of Primary Industries, Victoria), Jan Rowland (The Department of Water, Land and Biodiversity Conservation, SA), Phil Goulding and Nishita Parmer (Department of Agriculture and Food, Western Australia) and in particular Ian McGowan (NSW Department of Primary Industries) who also set up a template that was subsequently used by all the other GIS scientists.*

Farmer and researcher case studies within the document have been adapted from articles in SALT, Future Farm *and* Focus on Perennials magazines. *Thanks to Georgina Wilson, Don Nairn, Wes Seeliger, Don Price, Matt Crosbie and Dr Daniel Real for writing the original articles featured in this publication.*

The economics section is an important component of the Prospects Statement *and has been based on articles and reports by Dr Daniel Real and Dr Graeme Doole, Dr Dean Revell and Dr Marta Monjardino, Craig Beverley and colleagues, and Andrew Bathgate and Professor David Pannell.*

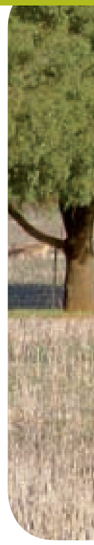
Finally thanks and gratitude must be given to Dr Daniel Real, Dr Brian Dear and Roy Latta who kindly spent the time reviewing the final document.

Photo: Richard Bennett

Prospects for perennials *author, Sarita Bennett*

About the author

Dr Sarita Bennett is a Research Fellow with the FFI CRC, based at the University of Western Australia (UWA). She has 15 years experience in the ecological and genetic adaptation of agricultural fodder plants to mediterranean climatic regions of Australia and Europe. Sarita completed her PhD at the University of Birmingham and the Institute of Grassland and Environmental Research in the United Kingdom, and has subsequently worked in WA for 12 years, initially with CLIMA and CRC Salinity and currently with FFI CRC. Sarita has particular skills in information analysis and synthesis and has been the co-author or co-editor of three books and has contributed to more than 40 other journal and book chapter publications. Sarita is currently a researcher on the SALTCAP (Saltland Capability Analysis Project) with the FFI CRC.



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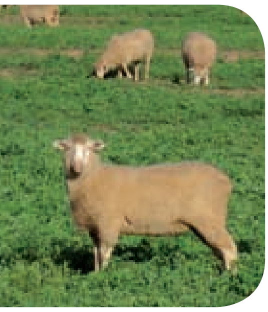

regions at a glance

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The prospects for widespread adoption of forage perennials

Rising water tables and increasing soil salinity led to the realisation that farming practises in southern Australia were unsustainable. More recently winter drought, in eastern Australia in particular, and out-of-season summer rain have emphasised the need to identify new perennial plants that can better cope with an increasingly variable climate. Until relatively recently lucerne was the only herbaceous perennial legume available for the medium- to low-rainfall region, although it is not adapted to low soil pH, waterlogged conditions or soil salinity and requires some summer rain. However, it possesses the key characteristics required for perennials in the medium-rainfall region, namely, a deep-rooting system and some summer activity to use out-of-season summer rain. These characteristics have been used in the search for other perennials to increase the diversity of species available.

Current challenges facing farming systems in southern Australia and the drivers for change from a reliance on annual legumes and grasses towards perennial legumes, grasses and herbs have been outlined in this *Prospects Statement*. A suite of species are available that fit into the high-rainfall regions of southern Australia, with a limited but growing number available for medium-rainfall regions. However, there are few options available for the low-rainfall region and many environmental niches within the medium- and high-rainfall regions where there are no perennial options.

summary

PHOTO: Pamela Lawson

PHOTO: Leah Lane, NSW DPI

To find species or new cultivars that will fit into areas where there are currently gaps, germplasm acquisition and research partnerships were initiated through the former CRC for Plant-based Management of Dryland Salinity (CRC Salinity) and have been continued by the Future Farm Industries CRC (FFI CRC) in areas that have similar ecogeographic conditions as shown on page 42.

This *Prospects Statement* provides a description of the evaluation protocol followed through the discharge and recharge evaluation programs in the CRC Salinity, along with the weed risk assessment protocol that has become part of the initial evaluation. A section is included on the potential economic benefits of including perennials in the farming system, with examples given for a variety of perennial species in different parts of southern Australia. There are a variety of management issues that have to be addressed when including perennials in any farming system, including the development of new farming systems to deal with perennials, preparation and timing of establishment, the preference of perennials for rotational grazing rather than set-stocking and the associated labour increase and cost.

Southern mainland Australia is broken into 12 different growing regions within this *Prospects Statement* — (1) northern coastal plain, WA; (2) northern medium-rainfall wheatbelt, WA; (3) southern medium-rainfall wheatbelt, WA; (4) low-rainfall wheatbelt, WA; (5) south coast, WA; (6) mid-north and Yorke Peninsula, South Australia; (7) Eyre Peninsula and the Mallee, SA and the Mallee, Victoria; (8) upper south-east, SA and Wimmera and north-central catchments, Victoria; (9) temperate high-rainfall region: Adelaide Hills, Mt Lofty Ranges, Fleurieu Peninsula, Kangaroo Island and the lower south-east, SA and Glenelg-Hopkins and Corangamite catchments, Victoria; (10) Riverine Plains, Victoria and south-west slopes and Riverina, New South Wales; (11) central slopes, plains and tablelands, NSW; and, (12) north-west slopes and plains, NSW. Within each of these regions a table is provided listing the perennial options available, along with the currently registered cultivars, specific rainfall and soil type requirements, plus any extra important information about the species in particular.

At the end of the document there is a section *In the pipeline* on current research, focussing on perennials for the low-rainfall regions, in particular, and new perennial species under evaluation, along with a list in Appendix A of all the species evaluated through the discharge and recharge programs of the CRC Salinity.

The aim of this document

Incorporating perennials into farming systems across southern Australia opens up new opportunities for profitable and sustainable agriculture. Many producers are currently looking to adapt their farming systems to provide not only a profitable, but also a sustainable business for future generations. Knowledge offered by their experience is supported by a range of research to portray a heartening picture. This *Prospects Statement* captures the existing knowledge base about the use of perennial pastures and outlines the prospects for incorporating perennials into farming systems across Australia. Leading producers, their advisers, industry networks, natural resource management groups and research investors alike, can use this knowledge to inform investment and management decisions in respect to perennial pastures on farms, across catchments, regions or within program investment portfolios.

The drivers of change for a sustainable future

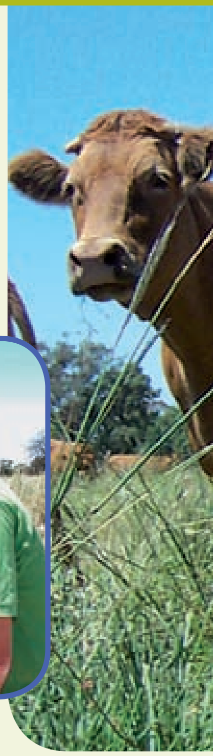


PHOTO: FFI CRC

Rising water tables, increasing levels of soil salinity and acidification were the initial drivers for change from traditional farming systems, based on rotations of annual legumes and crops, to a more sustainable farming system using perennials[1,2]. Contemporary drivers, such as the impact of climate change (changing water availability, pattern and variability across agricultural areas of southern Australia), alternative competing industries, technological advances in some forest product industries and a change in the economics of the forage industry have strengthened our resolve that perennials are an essential component to modern farming systems. It has been predicted that much of southern Australia will become warmer and drier with climate change[3,4].

Before European settlement, the vegetation of southern Australia was dominated by perennial woodland, shrubland or heath that was relatively deep rooted, drought tolerant and very effective in using available rainfall, so little entered the water table below. The water table was mainly deep below the surface and considered to be in dynamic hydrological balance[5], with the significant quantities of accumulated salt in the soil remaining immobile.

Large-scale grazing and tree clearing for cropping led to a shift from the predominantly perennial system to a shallow-rooted annual-based system that resulted in significant increases in the animal carrying capacity of the land and has provided nitrogen for crops when grown as part of a ley- or phased-farming rotation with legume pastures[6]. However, it has also led to increased rates of deep drainage that has resulted in mobilisation of stored salt deep in the soil profile[5].

It is now accepted that for water tables to return to pre-land clearing levels then perennial agricultural systems that mimic the water use behaviour of native vegetation are required[7].

The most cost-effective method of restoring the hydrological balance across the agricultural areas of southern Australia is to increase the use of deep-rooted perennial vegetation across large areas of the landscape[8-10].

During 2004, the total area of perennial-based farming systems in southern Australia was estimated to be about three million hectares out of a total of 100 Mha of cleared farmland[11]. The remainder of this land is dominated by annual species.

Driving change

What does it take to persuade landholders to change their farming system from an annual-based system to a perennial-based one?

The economics have to be favourable for them to consider a change, yet will this be apparent if they change the farm a paddock at a time?

How much of the farm should be under a perennial-based system for the landholder to reap the maximum benefit from having the perennials in the system? And how many years will the farm need to include perennials before the farmer will start to see the benefits and returns?

One of the obvious advantages of perennial pastures is they provide green feed at the time of the year when feed is at a premium and producers often have to supplement the feed available on the farm. Many producers who have adopted a perennial-based system have found the carrying capacity of the whole farm has increased, which means they can operate more profitably [12,13].

> *"Profitable perennials™ are pasture and forage species and cultivars that will improve the profitability and sustainability of livestock enterprises and cropping systems, and new short-cycle woody crops integrated with cropping and grazing."*
>
> **Kevin Goss, Future Farm Industries CRC CEO**

introduction

Providing the answers

This *Prospects Statement* will attempt to answer the questions outlined previously. A section is included on the economics of different perennial-based farming systems, what perennials are available, including a summary of our increased knowledge about perennial forages and the potential new varieties to emerge from research undertaken through the life of the CRC Salinity.

Southern Australia is broken into 12 regions and within each region a table of the suitable perennial grasses, legumes and herbs is provided. Further detail on each listed species can be found in *Appendix B*, along with a reference to a website providing further sowing and management guidelines.

Within each regional table, details are given of the rainfall, soil and any other constraints that will limit where each species is sown.

Five producer case studies are presented who have adopted perennials into their farming systems. They talk about their decision to include perennials in the system, the issues faced in changing the farming system to include perennials and their successes in doing so.

The final section of the *Prospects Statement* deals specifically with areas where there are still few perennial forage options available, including the low-rainfall areas of southern Australia, and details are given of potential for these target areas, and research areas that will be targeted by the FFI CRC.

Current available options

A decade ago, lucerne was the main perennial legume option available for most of the medium- to low-rainfall regions of southern Australia. Lucerne, however, has its limitations as it is intolerant of acid soils, waterlogging and soil salinity and requires some summer rain[14].

Lucerne can lower water tables with its deep-rooting system[9]. A search for perennial legumes with similar deep-rooting systems would provide further options for the agro-ecological zones where lucerne is not successful. Ideally a suite of perennial options is required to fit the ecologically niches currently filled by annual legumes.

White clover is the only other perennial legume sown extensively in southern Australia, although its use is restricted to permanent grazing regions receiving more than 700 millimetres annual rainfall, as it does not persist in lower-rainfall regions due to a lack of drought tolerance[6].

More perennial grass options are available including the temperate C3 grasses such as perennial ryegrass, tall fescue, phalaris and cocksfoot, the sub-tropical C4 grasses such as kikuyu and Rhodes grass, and the halophytic grasses tall wheatgrass and puccinellia, which are suited to saltland pasture areas of southern Australia.

The temperate grasses are all restricted to the medium- to high-rainfall regions of southern Australia and, other than temperate types of tall fescue, are shallow-rooted, therefore contributing little to lowering the water tables[15].

The subtropical grasses have more summer activity, therefore contributing more to water use during out of season rains. Other than kikuyu and Rhodes grass, their use has generally been restricted to the summer-dominant rainfall zones of Australia, although research is currently underway on expanding their use into winter-dominant rainfall zones with some summer rain or with a shallow or perched non-saline water table[16].

In discharge areas[a], with waterlogging and soil salinity constraints to production, the options available are also limited. Puccinellia and tall wheatgrass are tolerant of both soil salinity and waterlogging and will grow successfully, but there is a lack of perennial and annual legume options available. The annual legume, balansa clover, is productive on waterlogged soils, but is not as salt tolerant as originally thought, particularly during germination[1,17]. The perennial legume, strawberry clover, is also tolerant of waterlogging, but is not salt tolerant.

Identifying new salt- and waterlogging-tolerant legumes that can increase levels of nitrogen in the soil for companion grass species, thus increasing their nutritive value to livestock, is a high priority[6].

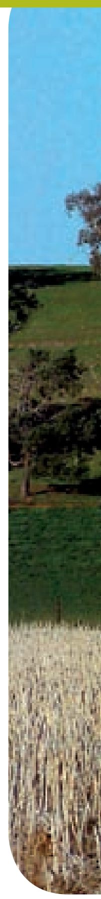
Perennial legumes also have an advantage over annual legumes as they provide out-of-season feed, increase carrying capacity and reduce the need for supplementary feed during autumn[16]. Salt-tolerant shrubs such as saltbush are valuable for lowering the water table in these environments. However, they accumulate high levels of salt and as a consequence have a high ash content that contributes no nutritive value[18]. Livestock grazing these shrubs are thus unable to meet their energy requirements and require high quality leguminous species as companion understorey plants to achieve desired growth rates.

How *Prospects for perennials* helps

This publication outlines the prospects for including perennials in mixed farming systems in southern Australia.

It covers:

- The causes and impacts of land clearance and annual plant-based farming systems in southern Australia; evolution of change in farming systems and current perennial options (*The drivers for change for a sustainable future*; pages 8–10)
- Climate and landscapes where perennial pastures are targeted within the *Prospects Statement*, evaluation procedure of new material and weed risk protocol (*Prospects for perennials*; pages 11–18)
- Economic implications of including perennials in farming systems; permanent pastures, pasture cropping, lucerne, forage shrubs and pre-experimental evaluation (*Factors affecting* Profitable perennials™; pages 19–31)
- Challenges of managing perennial pastures; rotational grazing, successful establishment and final removal; (pages 32–35)
- New species under development, their development and commercialisation, plants for the low-rainfall zone, saline and discharge environments of southern Australia (*In the pipeline*; pages 36–41)
- Region-by-region recommendations for including perennials in mixed farming (*Regional prospects for* Profitable perennials™ *in mixed farming*; pages 42–43)
  - **Western Australia** — northern coastal plains, northern and southern medium-rainfall wheatbelt, low-rainfall wheatbelt and south coast (pages 44–57)
  - **South Australia** — the mid-north and Yorke Peninsula, Eyre Peninsula and Mallee, south-east, Adelaide Hills, Mt Lofty Ranges, Fleurieu Peninsula and Kangaroo Island (pages 58–68)
  - **Victoria** — Mallee, Wimmera, north-central, Riverine Plains and Glenelg-Hopkins and Corangamite catchments (pages 59–70)
  - **New South Wales** — south-west slopes and Riverina, central slopes, plains and tablelands, northern slopes and plains (pages 69–75)
- Species included in field evaluations (pages 77–82)
- Perennial species references (pages 83–84)
- References (pages 85–89).



[a]Discharge areas are parts of the landscape where water flows out from an aquifer or from groundwater through the soil or along the surface.

PHOTO: Catriona Nicholls

Perennials for the farming systems of southern Australia

Southern Australia has been broken down into different agro-climatic zones[19] with different plant growth potential linked to temperature, moisture and light. The agro-climatic zones in southern Australia are provided in Table 1, along with the dominant land use in each zone.

This *Prospects Statement* concentrates on the search for perennial plants for the medium- (650–400 mm/yr) to low- (<400 mm/yr) annual rainfall agricultural regions of southern Australia (E1, E2 and E3 in Table 1). This is an area of southern Australia for which there are currently few perennial options, despite being subject to the same sustainability issues as other regions of southern Australia, particularly rising water tables and increasing soil salinity.

Forecasts of climate change predict a reduction in annual rainfall, along with increased unreliability. It is also a region where the economic margins are low and therefore there is a requirement for the adoption of any new pasture species to be profitable compared with current systems.

In winter-rainfall dominant mediterranean-type climate areas of southern Australia, perennials need to be able to cope with the stress of summer drought. However, few commercial perennial species are well adapted, particularly in medium- and low-rainfall areas of this zone, largely because most come from more temperate regions.

TABLE 1: Agro-climatic classification of areas of southern Australia targeted for perennial pasture plant improvement, along with current dominant landuse and options for including perennials in the farming system[19]

CLIMATIC DESCRIPTION CODE REFERENCE FROM[19]	GEOGRAPHIC OCCURRENCE	CURRENT DOMINANT LAND USES	PERENNIAL OPTIONS
Temperate, cool season, wet, high rainfall (D5)	Tasmanian lowlands, southern Victoria and NSW tablelands	Forestry, sown permanent pastures and horticulture	Options available: white clover and temperate grasses
Classic 'mediterranean' climate with cool, wet winters and warm to hot, dry summers (E1)	South-west WA and southern SA	Winter cropping and sown pastures (animal dominant), forestry and horticulture	Limited options: lucerne plus new options emerging
Mediterranean climate with drier, cooler winters than E1 (E2)	Inland of E1 in south-west WA, southern SA, north-west Victoria and southern NSW	Winter cropping, improved pastures (cropping dominant)	No options. New thinking required. See text for emerging ideas
Temperate, sub-humid (E3)	NSW western slopes	Winter and summer cropping, sown and native pastures, horticulture	Limited options: cocksfoot and tall fescue plus new options emerging

Adapted from Ewing[20] and Bennett[21]

PHOTO: Ben White

Recharge landscapes

The requirement for plants in recharge[b] environments is to reduce groundwater recharge, which leads to rising water tables, dryland salinity and soil acidification[1,8]. Through a combination of a deep-rooting habit, persistence, summer activity and the ability to respond to summer rain well-adapted perennial plants could address recharge.

For landholders to change farming practices, perennials also need to have superior herbage production. Currently, lucerne is the most widely grown perennial legume in the cropping zone of southern Australia. It has a longer growing period, compared with annual legumes and in the eastern states produces a higher biomass, providing valuable grazing. It also increases the soil nitrogen for the subsequent crop and can dry out the soil profile[9,22]. However, it is limited by a number of factors including intolerance to soil acidity and waterlogging, risk of bloat and lack of persistence under set stocking[1].

"I think we have learnt a lot through our failures. Even with lucerne we've made every mistake you can make — from sowing on acid soil, to overgrazing and not controlling insects. But as a result we know a fair bit about what it can and can't take."

Nick Trethowan, mixed farmer, Kojonup, WA

The legume component of the former CRC Salinity's national field evaluation program set out to identify new deep-rooted perennial legumes that were persistent, highly productive and had the potential to decrease groundwater recharge in the mixed farming zone of southern Australia[23]. The perennial herb chicory 'Grasslands Puna', was the only species in the study to show comparable persistence and production to lucerne 'Sceptre' under both favourable and acid soil conditions. At a site with high subsoil acidity and high exchangeable aluminium, Grasslands Puna showed superior production, confirming reports that chicory is more acid tolerant than lucerne[24]. However, the cultivar Grasslands Puna was not bred for Australian conditions and there is potential to develop cultivars with improved drought and grazing tolerance[23].

Other species showing some promise in recharge environments are hairy canary clover (*Dorycnium hirsutum*), sainfoin 'Orthello', sulla and the Australian native, tall verbine (*Cullen australasicum*). However, all of these species displayed factors that will limit their immediate or large-scale application in these environments.

[b]Recharge areas are those parts of the landscape where excess rainfall drains past the root-zone and reaches the water table.

Hairy canary clover produced moderate herbage yields and persisted well in both favourable and acid soil sites. It is more acid tolerant than lucerne[25] and shows a similar water use[26], but is slow to establish and has low forage quality, which may limit its adoption. Sainfoin is adapted to neutral to alkaline soils. It also had moderate herbage yields and is non-bloating. However, its establishment and persistence need to be improved before it can be recommended for inclusion in perennial pastures.

Sulla is a biennial or short-lived perennial adapted to well-drained, fertile loamy soils. It showed best production in the second year, but poor persistence beyond this, as expected. This species shows promise for a phased pasture-crop farming system where a short-term pasture phase is required[8]. Tall verbine showed similar persistence to lucerne during a three-year period in southern NSW, but is less palatable[27]. This species is thought to be best suited to low-rainfall, extensive, low-input farming systems where its low palatability will help to ensure its survival.

Perennial grasses are widely used, mainly as permanent pastures in high-rainfall areas. However, they have the potential to be extended to the medium- to low-rainfall mixed cropping systems of southern Australia.

Perennial herbs also have a potential role in these systems as they can provide high nutritional feed late into the season[28].

The grass component of the former CRC Salinity's national field evaluation program identifed new deep-rooted perennial grasses and herbs that were persistent, highly productive and had the potential to decrease groundwater recharge in the mixed farming zone of southern Australia. The temperate grasses were generally more productive than the subtropical grasses and perennial herbs, with perennial ryegrass 'Avalon', tall fescue 'AU Triumph' and 'Resolute Max P', cocksfoot 'Porto' and phalaris 'Holdfast' and 'Australian' showing the best production across the range of sites, although best summer production was found in Porto and Rhodes grass 'Katambora'[29]. However, summer activity reduced persistence in the temperate grasses in the low-rainfall areas and it is suggested that some summer dormancy is required in the development of plants for low-rainfall regions[30].

A specific research project on the development of perennial grasses for the low- to medium-rainfall environments focussed on the evaluation of accessions and cultivars of tall fescue and cocksfoot that exhibited increased summer dormancy or facultative dormancy; where they remain active until there is little soil moisture available[31].

Breeding activities on both species have been historically focussed on higher-rainfall environments, although their potential to be extended to drier environments has previously been identified[32]. The two species have different ecological niches within the low- to medium-rainfall environments; tall fescue is tolerant of some waterlogging and mild salinity, whereas cocksfoot is better adapted to low pH, high aluminium soils with low levels of soil fertility. In both species, currently available cultivars were found to be inferior in terms of production and particularly persistence, compared with the accessions of Mediterranean origin obtained for the evaluation program.

Three lines of tall fescue from east Sardinia were selected as having the best establishment, production and persistence compared with the control cultivar, 'Demeter'. These lines will be taken forward into a breeding program along with three lines of north African origin which appeared to exhibit facultative summer dormancy[33].

Four synthetic varieties of cocksfoot were developed from the selected Mediterranean accessions. These were based on the accessions that showed the best yield and persistence during the dry summers of the trial period[33].

Puccinellia is productive and persistent in waterlogged and highly saline areas

Discharge landscapes

In waterlogged and highly-saline soils there are currently no perennial legumes available, shown by their lack of persistence into the second year of field evaluation trials[34]. In the discharge environment component of the CRC Salinity's national field evaluation program, lucerne persisted in higher-rainfall environments, but in medium- and low-rainfall environments the combination of waterlogging, low rainfall and saline soils meant it did not survive the first winter[34], despite being reported to have some tolerance to saline conditions[35]. It is interesting to note that 'Salado' showed no advantage over 'Sceptre', despite being selected and promoted for salinity tolerance at germination[36].

Strawberry clover performed well at low saline, high rainfall environments, but is not tolerant of either saline or drought conditions. Birdsfoot trefoil, narrow-leaf trefoil and greater birdsfoot trefoil also showed waterlogging tolerance, with narrow-leaf trefoil also showing some tolerance to mild salinity. However, the lack of persistence of the other two species may be due to a lack of drought tolerance, rather than a susceptibility to saline conditions[37]. In contrast sulla performed well under saline conditions, but was unable to persist under the combined conditions of waterlogging and high salinity[34].

The two perennial grass options available for saline or waterlogged soil are puccinellia and tall wheatgrass.

Puccinellia is the most productive and persistent grass species on waterlogged, highly saline soils too hostile for other temperate grass species. In fact, it appears to require both waterlogging and saline conditions as it did not persist on mildly saline or non-waterlogged sites. There is currently only the one cultivar available in Australia, 'Menemen', although higher herbage production of another line suggests that there is the potential to select for more productive genotypes of the species[34].

Tall wheatgrass has a similar level of salt tolerance to puccinellia, but is not as tolerant of highly waterlogged conditions[38]. Two cultivars are available, 'Dundas' and 'Tyrell', although little difference was observed in both performance and persistence across all the discharge evaluation sites. Tall wheatgrass was found to show a wide adaptation to soil pH[39]. However, its potential for future application will be constrained by risks associated with environmental weediness.

At sites where levels of salinity are not high, phalaris, tall fescue and ryegrass may have a role. Ryegrass is restricted to areas receiving more than 600 millimetres annual rainfall, but summer-dormant cultivars are available of phalaris and tall fescue that may be suitable for lower-rainfall environments[15,29].

PHOTO: Jo Kirkpatrick. INSET: Matt Crosbie

Evaluation of promising material

A review[1] and a scoping study[40] identified perennial legume, grass and herb species that showed potential for the recharge areas of southern Australia. A second scoping study[41] identified promising legume, grass and herb species for salt-affected areas. A priority list of species for further evaluation was developed following the preliminary assessment of material from the collection missions, genetic resource centre introductions, and material identified in the scoping documents. Priority species targeted for the medium- to low-rainfall regions were those that were deep-rooted with the potential to lower water tables and those that were adapted to waterlogged and saline soils.

These species were the subject of a nationally coordinated evaluation program across southern Australia through the CRC Salinity[37]. A full list of all the species included in the evaluation program is provided in *Appendix A*.

A number of new species are at an advanced stage of evaluation with each species showing adaptation to particular ecological niches within the farming system. Identified priority species with potential for immediate application are shown in Table 2.

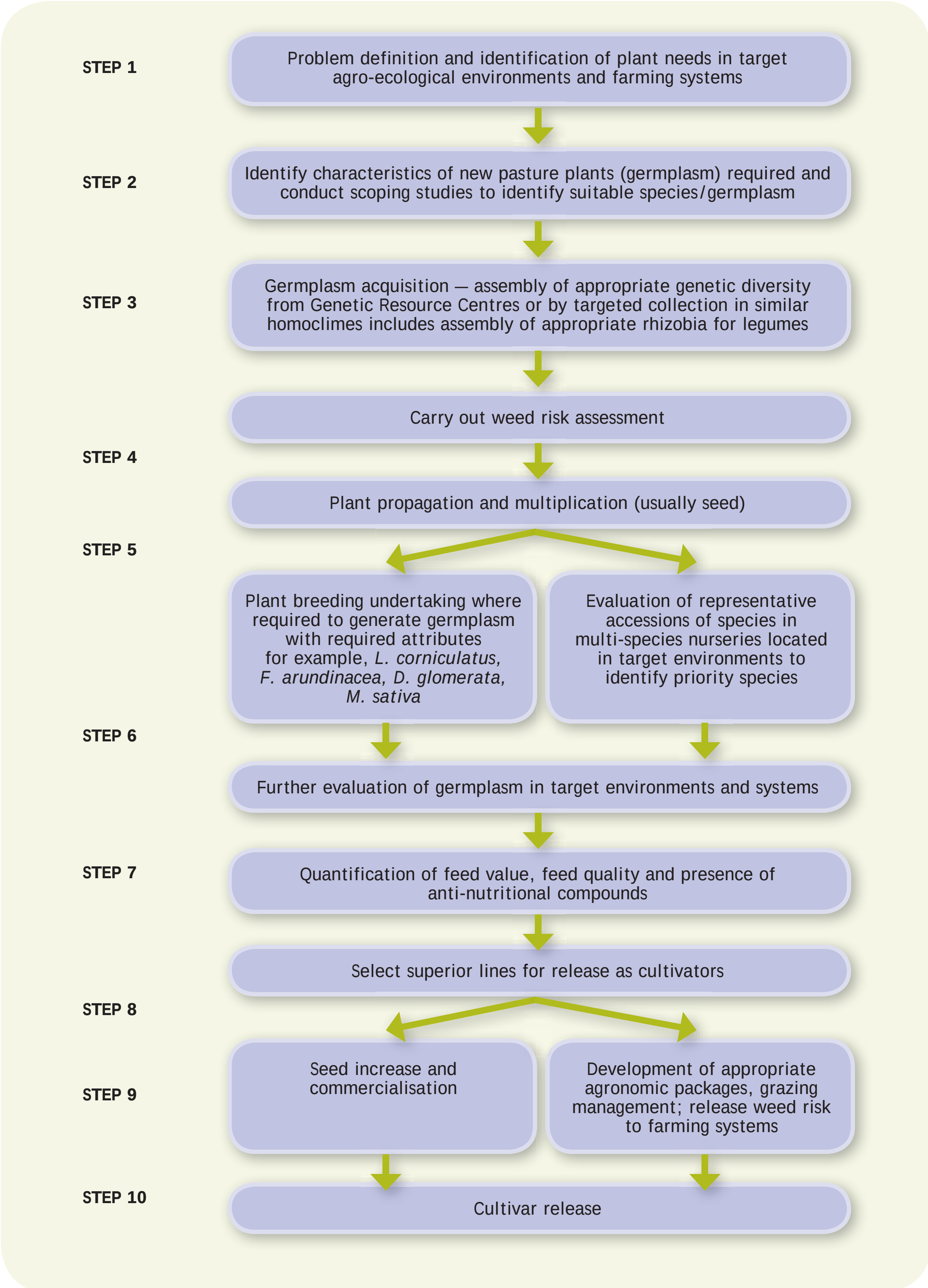
The development of a new cultivar follows a strict sequence of events from the initial identification of a requirement for a new species or cultivar for a targeted agro-ecological environment through to the release of a new cultivar. The sequence of events is shown in Figure 1 (over page).

TABLE 2: Status and breeding priority of perennial legumes, grasses and herbs for the medium- to low-rainfall agricultural regions of southern Australia, identified in CRC Salinity evaluation trials

PLANT SPECIES AND PRIORITY RATING	TARGET LANDSCAPE AAR (average annual rainfall)	AGROECOLOGICAL NICHE
Birdsfoot trefoil (*Lotus corniculatus*)[A,B,C]	D5, E1, E3 (breeding for E2)	More tolerant of acid soils than lucerne and can tolerate some waterlogging; breeding in progress for increased drought tolerance
Chicory (*Chichorum intybus*)[A,C]	D5, E1, E3 Recharge environments	High livestock feeding value and anthelmintic properties; superior acid soil tolerance compared with lucerne
Cocksfoot (*Dactylis glomerata*)[A,B,C]	Summer-dormant cultivars D5, E1, E3	Summer-dormant cultivars highly productive in autumn–winter; breeding in progress to extend to E2
Lucerne (*Medicago sativa*)[A,B,C]	D5, E1 Freely draining environments	Superior drought tolerance and persistence to other perennial legumes; potential to increase tolerance to aluminium and waterlogging
Phalaris (*Phalaris aquatica*)[A,C]	D5, E3 (breeding for E1)	One of the most productive and persistence grasses; summer dormancy increases persistence in lower-rainfall regions; some waterlogging tolerance; potential to increase salt tolerance
Puccinellia (*Puccinellia ciliata*)[A,C]	E1-E2 Highly saline, waterlogged environment	Appears to require significant waterlogging to ensure persistence
Rhodes grass (*Chloris gayana*)[A,D]	E3 Requires significant proportion summer rain	Poor persistence where cold, wet winters; moderate salt tolerance; breeding to extend to E1
Strawberry clover (*Trifolium fragiferum*)[A,D]	D5, E1 Poorly drained environment	Best performance on poorly drained and heavy clay soils low in landscape; best performance on soils that are moist during summer
Sulla (*Hedysarum coronarium*)[A,D]	D5, E1, E3 Well-drained soils	Short-lived perennial; thought to possess moderate salt tolerance, but lacks waterlogging tolerance
Tall fescue (*Festuca arundinacea*)[A,B,C]	Summer-dormant cultivars E1, E3	Summer-dormant cultivars showing improved persistence; breeding program in progress
Tall wheatgrass (*Thinopyrum ponticum*)[A,D]	E1-E2	Highly persistent across diverse range of sites; salt and waterlogging tolerant, but not as tolerant of waterlogging as puccinellia; assessed as an environmental weed in some regions
Wallaby grass (*Austrodanthonia caespitosa*)[A,B,C]	E1-E2 Low input pasture	Persistant; new cultivar being developed

Adapted from [21,37] [A]Cultivars available for immediate use; [B]Breeding in progress; [C]Further breeding a high priority; [D]Further investigation warranted

FIGURE 1: Sequence of events in the development of new pasture plants to meet production and sustainability goals



Researchers have used the protocol to assess the potential weed risk of Enrich™ *species such as* Rhagodia preissii

Environmental Weed Risk Protocol

Stringent border quarantine procedures were introduced by the Australian Quarantine Inspection Service (AQIS) during 1997[58] to reduce the risk of weed species being imported into the country. However, at that time there were no national post-border protocols for assessing and managing weed risk on species already present. Development of an Environmental Weed Risk Assessment (EWRA) model, based on the principles of the National Post-border Weed Risk Management Protocol[59], was initiated by the CRC Salinity[58] and is continuing through an FFI CRC *Biodiversity and Water* program project to monitor and minimise the weed risk that new species or cultivars posed to natural ecosystems.

The CRC's Environmental Weed Risk Protocol (EWRP) ranks species on the basis of invasiveness, impact and potential distribution using published information, experimental observations and prior knowledge of pasture breeders and weed experts.

The impacts criterion contains seven questions that relate to a species impact on the environment. Published information on the impact of a forage species is only available for a limited number of species with a long history in Australia and forage breeders are encouraged to use their own experience plus that of weed experts to answer these questions.

TABLE 3: Stages in the implementation of a plant improvement program[20] and corresponding weed risk management activities[58]		
	PLANT IMPROVEMENT ACTIVITY	**WEED RISK MANAGEMENT ACTIVITY**
1	Define the problem; develop plant improvement goals and objectives	Determine whether the introduction of new species is required
2	Acquire germplasm	Check Federal Permitted Seeds list; pre-border* weed risk assessment
3	Selection and breeding	Post-border** weed risk assessment; implement experimental site hygiene practices
4	Testing under field conditions	Post-border weed risk assessment; implement experimental site hygiene practices; implement experimental site conclusion hygiene practices
5	Commercialise cultivar	Develop management guidelines to minimise weed risk

*Assessment of species before entry into Australia performed by Biosecurity Australia (a portfolio agency in the Australian Government Department of Agriculture, Fisheries and Forestry).
**Assessment of species post-entry to Australia.

The potential distribution criterion of a species is assessed using a Geographical Information System (GIS) and includes information on the species current geographic distribution, an analysis of its climatic preferences, soil preferences and land-use. For further information on the EWRP including the specific questions asked within each criterion, visit the weed risk section of the FFI CRC website (www.futurefarmcrc.com.au).

The model has been designed to address the need for environmental weed risk management in forage improvement programs. Selection and breeding of new forage species typically follows a five-stage process from problem definition through to the commercialisation of a new cultivar[20]. Table 3 lays out specific weed risk management activities that should be implemented at each stage of the forage breeding program.

If a species has not been through a weed risk assessment previously, then the model detailed above should be applied. This results in an overall weed risk score related to a particular management action depending on the weed risk. The scores range from a worse case scenario of 'do not commercially release or promote the species', through to 'further analysis and management plan required', or where the species is designated a low or negligible weed risk and no further assessment is required.

PHOTO: Jason Emms

PHOTO: Don Price

Factors affecting profitable perennials™

This section of the *Prospects Statement* deals with the economic benefits of perennial pastures in different regions and factors that influence their profitability, drawing on recent contemporary analysis. While not all perennials or regions have been assessed, many of the conclusions drawn can be applied beyond the study regions.

Studies have shown that perennial pasture species are profitable in medium- and high-rainfall regions of southern Australia, with most analyses indicating that whole-farm profit can be increased through changes in both the distribution and the quality of feed, which leads to improvements in the livestock carrying capacity of the whole system. However many producers who establish perennial pastures, initially do so on smaller areas than the economic analyses would suggest is optimal, thus potentially undervaluing whole-farm impact. Few studies have taken place in low-rainfall areas and two emerging perennial options are discussed at the end of this section.

The FFI CRC aims to have a range of perennial pasture options available for adoption across a wide area of temperate, southern Australia during the next 20 to 30 years. However, for adoption to occur at the desired scale on-farm, the perennial technologies need to have a greater relative advantage compared with the existing practice they are to replace, and if possible be less complex and compatible with current farming systems[42]. In reality many of the available perennial options have greater costs and risks, with delayed returns, and are more managerially complex than current practice.

Experience with lucerne has highlighted some of these issues. For instance, lucerne is best adapted to fertile soils; the same soils best suited to annual crop production. Therefore it competes as a landuse with the crop on those parts of the farm where the opportunity costs associated with cropping are greatest[43]. Also, to realise the maximum benefits of growing lucerne requires a significant investment with a higher risk of establishment failure compared with the cropping alternatives, and it is a more complex system to manage, mainly because of the requirement for rotational grazing.

To realise its full benefit lucerne, ideally requires an integrated set of enterprise changes, which is not easy to trial on a small scale. Finally, lucerne does not fit profitably into large areas of the landscape, further limiting its use and adoption. It is intolerant of acid and waterlogged soils, and sandy-surfaced paddocks sown to lucerne are susceptible to wind erosion[6].

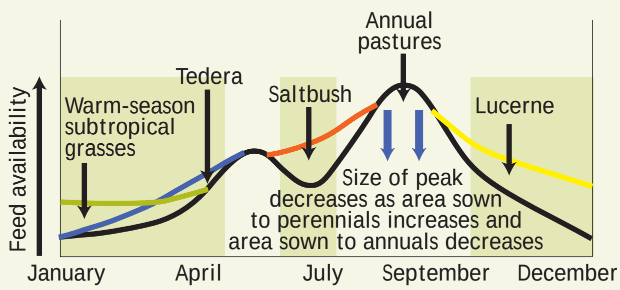
However, perennials do offer a new and complementary feed option to that provided by annual pastures and crop residues. The timing of forage production and feed availability is important as the value of extra feed changes during the year, increasing in relation to the most constraining time for livestock feed supply (see Figure 2)[44].

Perennials can access water at times when annuals are inactive (i.e. in response to out-of-season rainfall events). This characteristic means including perennials in the system provides a source of feed for livestock at times when the alternative is often high-cost supplementary feed or stored fodder. Variations in the degree of summer and autumn activity mean growing a spread of perennial species can provide greater diversity to the feed base throughout the year.

Lucerne is best adapted to fertile soils and has to compete with annual crops for landuse

A selection of different case studies are detailed in the following pages. As stated previously, while these case studies have been carried out in a particular region, the species grown and the farming system employed provide insights applicable beyond the specified region. In most of the regions discussed in this prospect statement, lucerne is a profitable part of the farm business. The role and profitability of the lucerne is detailed in the publication *Lucerne Prospects*[43] and only a brief summary is presented here.

FIGURE 2: Feed availability of pastures during the year*



*Areas highlighted for four perennial options indicate the time of year they will have the most impact. Most of the species also provide some feed at other times. Beige-coloured boxes highlight the times of year when additional farm-produced feed is required to avoid the use and cost of supplementary feed.

EverGraze®: Perennials in dryland farming systems

Optimising perennial combinations on the south coast of Western Australia

When *EverGraze*® was initiated by CRC Salinity and Meat and Livestock Australia (MLA) as a new grazing system for the high-rainfall (>550 mm) zone of southern Australia, the aim was to incorporate perennials into farming systems to increase profit by 50 per cent and to reduce water leakage past the root zone by 50%. Whole-farm models were used to identify livestock systems that met the *EverGraze* goals. *EverGraze* now has established six research Proof Sites across southern Australia where new farming systems that increase profits and improve the environment are being tested. It also has more than 55 on-farm demonstration Supporting Sites where producer groups trial new grazing systems on a commercial scale in their local environment.

The WA component of *EverGraze* was based on an analysis of a 2000 ha representative farm in the Albany Eastern Hinterland Catchment with three soil types – deep sands, shallow sand over clay and deep sand over clay.

MIDAS, a farming system modelling program[45],was used for the analysis, with a livestock enterprise of a self-replacing Merino flock using surplus ewes for crossbred lamb production.

Leakage values were estimated using a farm-scale hydrologic model[46]. Three different farming systems were analysed;

1. Traditional farming system – 30% crop, 70% annual pasture (subterranean clover-based), stocked at 8.5 dry sheep equivalent per hectare (DSE/ha)
2. Current best practice – 30% crop, 23% annual pasture (subterranean clover-based), 47% perennial pasture (either lucerne alone or kikuyu-subterranean clover), stocked at 10 DSE/ha
3. Future farming system – 30% crop, 70% perennial pasture (either lucerne alone or kikuyu-subterranean clover or tall fescue-subterranean clover), stocked at 12 DSE/ha.

PHOTO: FFI CRC

Introducing perennials such as lucerne were shown to increase yields of quality pasture, reducing the need for supplementary feeding

Modelling simulations suggested a meat enterprise would be more profitable than wool on all the farms analysed[47]. The major benefits of introducing perennials into the farming system were:

- Increased carrying capacity
- Higher pasture yields
- Superior feed quality during summer and autumn
- Reduced supplementary feeding[48].

Increasing the proportion of the farm under perennials (from 0% to 70%) had the benefit of increasing farm profit (from $32 to $82/ha/yr) and reducing leakage (from 69 to 23 mm).

PHOTO: Tim Prane

Although the Merino meat enterprise could meet the target of reducing groundwater recharge by 50% under the future farm system, it could not increase profit by 50% (see Figure 3). Further simulations suggested this would require an increase in the weaning percentage from 92% to 104%, or by increasing winter pasture production by 27%.

Further simulations were carried out using MIDAS on the 2000 ha representative farm to determine the optimum area of the farm sown to various perennial combinations[48].

Figure 4 shows how complementary perennial pastures can be used to increase farm profit. For example, with only one perennial option, in this case lucerne, the optimum proportion of the farm is about 25% (500 ha) in terms of profit. By increasing the number of perennial options to three, in this case lucerne, kikuyu and tall fescue, all with different growth patterns, the optimum area reaches 75% of the farm with a potential maximum profit of $82/ha/yr.

EverGraze® is a Future Farm Industries CRC, Meat and Livestock Australia and Australian Wool Innovation research and delivery partnership.

For more information about *EverGraze* visit:
www.evergraze.com.au

Contact: Geoffrey Saul
National *EverGraze* Coordinator
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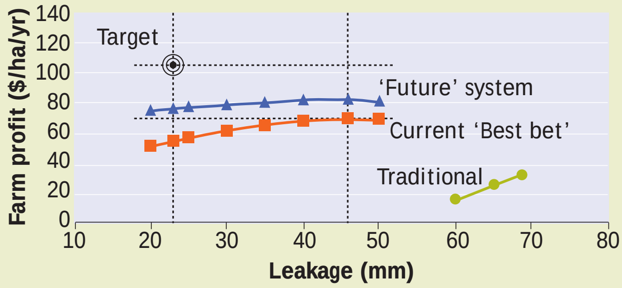
Email: geoff.saul@bigpond.com
Mobile: 0419 328 590

FIGURE 3: Trade-off between profit and leakage below the root zone of a range of farm systems based on MIDAS modelling of a meat Merino enterprise in the Albany Eastern Hinterland, WA



Adapted from[47]. The target of a 50% reduction in leakage and 50% increase in profit is identified alongside the respective axes

FIGURE 4: Modelled profitability and area sown of complementary perennial pastures, south coast, WA[48]

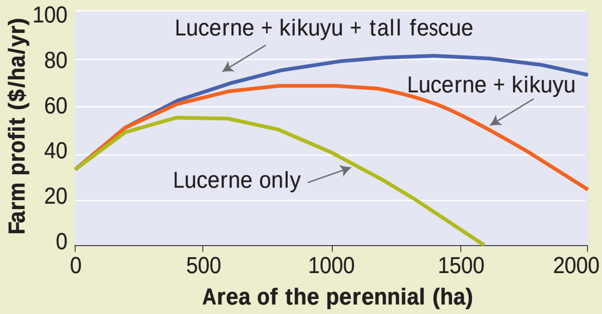


PHOTO: Pamela Lawson

Winter cropping capitalises on the winter-dormant phase of native perennial grasses to produce a cereal crop

Grain and Graze: Pasture cropping

Increasing summer-active native grasses in central-west New South Wales

Grain and Graze is a collaboration between the Grains Research and Development Corporation (GRDC), MLA, Australian Wool Innovation Limited (AWI), and Land and Water Australia (LWA). The main targets of *Grain and Graze* are to increase farm profitability by 10%, through a 5% increase in grain yields and a 10% increase in livestock production; improve natural resource conditions on-farm and develop mixed-farmers who are confident and able to make sustainable production decisions.

In central-west NSW these targets were explored through the potential of increasing summer-active native grasses and incorporating these pastures within the annual cropping cycle. The result is a system known as pasture cropping, where an annual winter crop is sown into a grass pasture at the start of its winter dormant phase. Central-west NSW has an annual rainfall between 580 and 700 mm with an even rainfall distribution across the year. Livestock is the dominant agricultural enterprise. Cropping typically occurs on about 20–25% of the farm at any one time, with a maximum of 40% of the farm available for intensive cropping. Lucerne is suited to the region's climate and is sown extensively. Native pastures occur where soil types are unsuitable for lucerne.

The MIDAS model based on the central-west slopes[49] was used for the analysis. Based on a 900 ha representative farm, the model was used to determine the influence of four different production factors on the profitability of pasture cropping in central-west NSW. These factors included pasture growth of native pastures and their quality during summer, the yield of the wheat crop and the commodity prices of grain, wool and prime lambs[50]. The model was run as simulations for farms with two different soil mixes — (1) an average mix of soil types for the region, where 30% of the farm is suitable for lucerne, and (2) a lower quality mix of soils where none of the farm is suitable for lucerne and crop yields are generally lower than for the best cropping soils.

For the average mix of soils in the region, pasture cropping increases farm profit by a maximum of $18/ha of native pasture, assuming wheat cropping occurs in two out of every four years, and profit is increased as the area of summer-active native grasses increases to 80 hectares compared with a farm containing no native grass.

However, the increase in farm profit is much greater in areas where soils are too poor for lucerne. In these regions, introducing pasture cropping is likely to markedly increase whole-farm profit (see Figure 5). Average profit increases were estimated using MIDAS as $54/ha at a low cropping frequency (one in four years of pasture) and $67/ha at a higher cropping frequency (two in four years). The optimum area under native pasture/crop is 150 to 200 ha for both cropping frequencies. Additional profit is realised in both soil type mixes through livestock production in response to the higher stocking rate of the farm. Whole-farm profit can be increased by around $10,000 on a 900 ha representative farm.

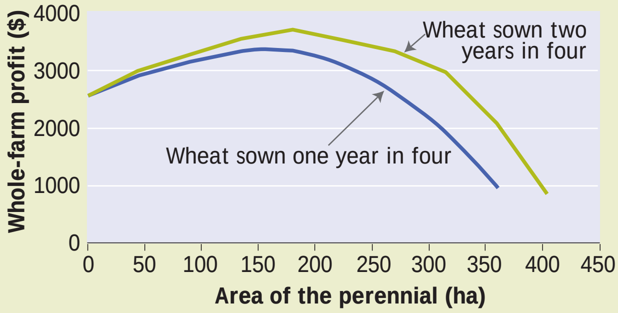
Factors that have a positive influence on the profitability of pasture cropping (see Figure 6) include:

- Yield of the crop sown into the dormant native pastures
- Production levels of the native grass
- Quality of feed (digestibility) from the native grass during summer.

This has important implications for pasture management, as pasture deferred for lengthy periods will decline in quality. A sharp reduction in profit will occur if pasture quality falls below the assumed level of this analysis. For example, an increase in pasture quality of about 5% would be sufficient to increase the benefit of pasture cropping to about $100/ha annually. However, a 5% drop in pasture quality, below that assumed in this analysis, would reduce the profit to near zero.

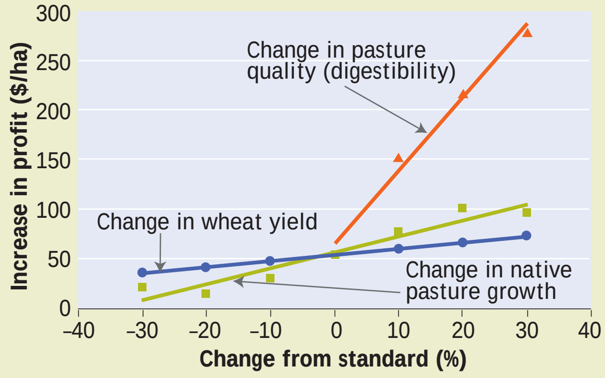
The net increase in farm profit is the result of two main changes in farm strategy — the increase in optimum stocking rate through the introduction of summer-active pastures and an increase in the area of wheat at the expense of winter pastures, canola and barley production. However, it is important to note that pasture cropping results in lower wheat yields and therefore a reduction in total crop income. This is more than compensated for by the increase in income from wool and meat that flows from the increase in stock numbers.

FIGURE 5: Whole-farm profit for different areas of native pasture for two different cropping frequencies, on a representative farm with a poor soil mix*[50]



*Zero area of native pasture implies no pasture cropping and provides the experimental control. Increases in per hectare profit are estimated by the difference in profit for a given area of native pasture and the control, divided by the area of native pasture

FIGURE 6: Influence of changes in relative pasture growth and quality and wheat yield sown in a pasture cropping system on the profitability of summer-active native pastures on the central-west slopes of NSW for a representative 900 ha farm



Lucerne

Central wheatbelt, Western Australia and Broken Plains, Victoria

MIDAS modelling was used for whole-farm economic analyses of the central wheatbelt, WA and the Riverine Plains, Victoria. Lucerne has the potential to increase water use compared with an annual pasture[51], but adoption of any perennial plant at a scale required to translate greater water use to dryland salinity prevention will depend on the economic viability of the option[52].

In both studies, benefits of including lucerne on-farm included reduced requirements for increased supplementary feed, increased carrying capacity of the farm and increased water use.

In WA, the central wheatbelt MIDAS model was used, which assumes a representative mixed farm of 1800 ha, made up of eight Land Management Units (LMUs) with up to 70% of the farm under crop. The predominant livestock enterprise is Merino sheep for wool production. Annual rainfall is about 350-400 mm. The study reported here involved simulating a repeating rotation of lucerne for four years, followed by two years of wheat, with the lucerne on a six-week rotational grazing pattern[53]. Annual pastures are still an important component of the farm enterprise. The option of running Merino prime lambs and crossbred lambs was included in the analysis.

PHOTO: Catriona Nicholls

A combination of lucerne and prime lambs is a profitable mix

When lucerne rotations were included in the wool production model, the outcome was marginal. The optimal total farm area sown to lucerne was 6% (see Table 4), increasing total farm profit by 3%, with the main economic benefit being the provision of summer and autumn feed, resulting in a decrease in supplementary feed requirements of 5 kg/DSE.

Including the option of prime lambs, but without lucerne, had a greater impact on profit, but the greatest increase in profit was realised when both lucerne and prime lambs were included in the model, increasing farm profit by 23% or $26,300/yr (see Table 4). Selling prime lambs increased the optimal area of lucerne from 115 ha to 215 ha and profit increased because the additional available feed provided by the lucerne increased the carrying capacity of the farm and provided feed of higher quality.

TABLE 4: Optimal farm plan with and without lucerne as a pasture option in the MIDAS central wheatbelt model[53]

	WITHOUT LUCERNE OR PRIME LAMBS	WITH LUCERNE ONLY	WITH PRIME LAMBS ONLY	WITH LUCERNE AND PRIME LAMBS
% profit change from base	–	3%	12%	23%
% of farm in crop	60%	59%	55%	54%
% of farm in annual pasture	40%	35%	45%	34%
% of farm in lucerne	–	6%	–	12%

PHOTO: Catriona Nicholls

The Broken Plains is part of the dryland farming section of the Goulburn-Broken Catchment Management Authority. It is a mixed farming region where cropping makes up about 60% of the farm area. Pasture is generally used by sheep (80%) and cattle (20%). Annual rainfall is less than 600 mm. The aim of the study in this region was to determine the agronomic and hydrological benefits of growing lucerne and to determine whether potential farm profits would be increased by including lucerne in the system compared with subterranean clover[54].

Farm systems incorporating lucerne were compared with farms using subterranean clover using information gathered from case studies, local agronomists and scientific researchers.

Subterranean clover rotations were generally four years of pasture, followed by six years of crop. Rotations including lucerne were generally six years of lucerne followed by six years of crop, and followed recommendations that hydrological balance could be achieved if 50% of the crop-pasture rotation was lucerne[55].

The benefits of including lucerne in the rotation resulted in increased dry matter production and subsequently higher stocking rates, provision of out-of-season green feed for finishing carry-over stock and fattening store lambs, high-quality silage and hay, increased weed control leading to lower costs for herbicide at the start of the cropping cycle. Soil structure was also improved, with less winter waterlogging on the duplex soils. Although crops yields in the first year of cropping were generally lower as a result of the drier water table, subsequent yields and grain quality were higher as a result of increased levels of soil nitrogen.

A region-level analysis was also carried out as part of the study. This comprised a financial analysis of all the farms in the Broken Plains with land at risk of becoming degraded leading to salinisation (110 farms with a total area of 85,000 ha) and showed that farming with lucerne resulted in a lower peak debt compared with subterranean clover and this debt was liquidated over a shorter period of time (see Table 5). Although initial machinery capital costs were higher with lucerne, these were offset in the first year of the analysis as the annual net benefit after tax of farming with lucerne was $34.9M compared with $27.7M for farming with subterranean clover — peak debt was also lower with lucerne. The financial feasibility analysis revealed that the option of farming with lucerne would be preferred to farming with subterranean clover because the peak debt was liquidated over a shorter time period.

TABLE 5: Financial analysis to show peak debts and pay-back periods from cumulative net cash flows for farms in the Broken Plains that could become degraded

	FARMING WITH LUCERNE	FARMING WITH SUBTERRANEAN CLOVER
Peak debt ($M)	183.7	189.4
Payback period (yrs)	8	12
Annual net benefit after tax ($m)	34.9	27.7

Enrich™

Including forage shrubs in the farming system

There are three main reasons why producers are interested in including forage shrubs in their farming system. These are to:

- Develop productive use of land that is unsuitable, or becoming unsuitable, for profitable grain production
- Reduce the risk of salinity, soil erosion or both
- Provide out-of-season feed and thus contribute to whole-farm profitability.

The details provided here are a summary of a report on farming with forage shrubs,[56] which is based on results coming out of the *Enrich* project. However, as forage shrubs are an option in mixed farming systems in the low- to medium-rainfall regions of southern Australia it is important to summarise the economics of including them here. *Enrich* is a FFI CRC, AWI, MLA and Joint Venture Agroforestry Program (JVAP) project focussed on developing better grazing systems through the use of perennial shrubs. An important assumption of the *Enrich* project is that forage shrubs alone will not provide enough edible biomass to support productive livestock enterprises[38]. Therefore the economic analysis is based on the assumption that they will be incorporated into the system with a pasture understorey[57].

PHOTO: Sarita Bennett

The Enrich *project focusses on developing better grazing systems through the use of perennial shrubs such as saltbush*

The central wheatbelt version of MIDAS was used for the modelling. Information input into the system was based on details from producers with practical experience of including forage shrubs in their farming system. These include tagastaste, with smaller areas of old man saltbush and golden wreath wattle (*Acacia saligna*) and an increasing area sown to *Rhagodia* species in the west Midlands of WA, and old man saltbush, with small areas of tagastaste in the central north and Eyre Peninsula of SA. Details of the representative farm for the central wheatbelt model are provided in the previous pages.

PHOTO: Dr Dean Revell

Results from the MIDAS modelling show that a farm with a higher proportion of marginal soils has a larger optimal area of shrubs (see Figure 7). For example, on a farm with 7% of its area classed as LMU1 (the poorest soil type), the optimal area to establish to forage shrubs is 10 to 20%, whereas on a farm with 15% of the land area as LMU1, the optimal area increases to 30%. Thus forage shrubs are likely to have the maximum impact on boosting economic returns in areas with lower rainfall, or those with low fertility soils.

In all scenarios, farm profit increased dramatically when the area established to shrubs increased from 0 to 10% and was optimal between 10 and 30%. Farm profit did not drop sharply until more than 30% of the farm area was established to shrubs.

A further interesting result of the MIDAS modelling was the impact of nutritional quality and quantity on farm profit. A level of 8 megajoules (MJ) of metabolisable energy per kilogram of edible Dry Matter (DM) was taken to be the average nutritional quality of the shrub and 2 kg edible DM/plant the average production quantity in the MIDAS model. Under these conditions on the typical farm, 10% of the farm established to forage shrubs maximises farm profit, with an increase in profit of 24% compared with no shrubs in the system[57]. However, if the biomass and in particular the quality of the feed increases, planting more than 10% of the farm becomes profitable.

FIGURE 7: Impact of changing the relative proportions of land management units (LMUs) on whole-farm profit across a range of shrub areas[56]

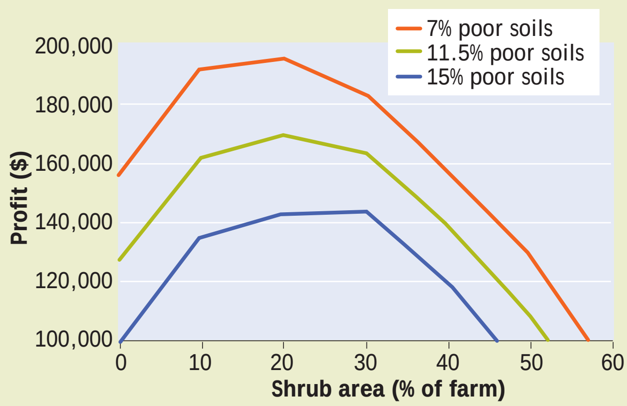


PHOTO: DAFWA

New perennial forage legume, Tedera, is being evaluated for use in mixed farming systems

Pre-experimental model of a new pasture species

Tedera — a new drought-tolerant perennial legume

Tedera (*Bituminaria bituminosa*) is a new perennial forage legume currently under evaluation in the central wheatbelt, WA. Success of a new forage species depends on its ability to fit into current farming systems and to fill environmental niches not occupied by current forage options. As there is a lack of extensive field experience, economic modelling has become an important part of the new species evaluation. The central WA wheatbelt MIDAS model was used to investigate the potential of this potential forage species in mixed farming systems. In the study, the options of using Tedera as a permanent pasture were considered as well as its use as the pasture element of phase farming systems. Also considered was the option of using a meat-producing livestock enterprise compared with the more standard wool-producing enterprise.

The study showed that Tedera fits into to a mixed-farming system by replacing annual pasture and partly by reducing the area sown to crops. The reduced cropping was clearly directed at soils where crop yields and profitability were most marginal. In the central wheatbelt, WA, poor crop yields are generally associated with acidic and infertile sandy soils.

Tedera performed best (generating greatest profit advantage) in scenarios when it was used as a permanent or long-term pasture rather than inclusion into phase rotations generally associated with the use of perennials such as lucerne.

A special feature revealed by this analysis was the importance of timing of the perennial pasture use. Tedera was mainly exploited as a source of late summer and autumn feed, made possible because of its observed ability to preserve summer growth as green leaf material despite summer drought conditions. This ability contrasts with perennials such as lucerne, which drop leaves under severe water stress.

Tedera could prove to be an option for the poor sandy soils of the central wheatbelt, WA

Having a predictable source of high-quality forage available out of the traditional growing season could provide an opportunity to increase stocking rate or reduce reliance on supplementary feeding, or both.

A profit advantage is fundamental as a driver for the adoption of new technologies such as that offered by Tedera. The MIDAS analysis undertaken in this study indicates that profit advantages in the order of 20% are possible.

The potential for profit was shown to be higher for a prime lamb production system (22%) compared with a more traditional wool production system (18%). Importantly the technology can be used with minor changes to the livestock production component of the farm.

The current analysis suggests Tedera has the potential to be a valuable pasture species in the central wheatbelt, WA context due to:

- Its adaptation to poor soils (acidic and infertile)
- Its ability for late spring and autumn production in all years and strong summer growth in wet years
- Its capacity to hold its leaves under the hot, dry summer conditions
- Flexibility in fitting as a phase or permanent element of pasture systems.

The model analysis indicates a potential for application on a significant scale (17% of the land area) irrespective of the nature of the livestock enterprise (wool or meat).

A surprising outcome of the analysis was that Tedera, with these inherent traits, was shown to have a greater potential for wide-scale uptake than lucerne, which is restricted to the more fertile parts of farms — the most profitable areas for intensive cropping.

The analysis shows that Tedera and lucerne do not compete as land uses, being applicable to different soil types.

PHOTO: Maree Doyle

Conclusion to factors affecting profitability of perennials

Six economic models of including perennials in mixed farming systems of southern Australia have been presented in this section. Although each example highlights the use of a different perennial, or combination of perennials, the results emerging from the analyses have many similarities:

1. Farm profit can be increased by including perennials in the farming system
2. Perennials provide quality out-of-season feed, reducing the need for supplementary feeding during summer-autumn and reducing costs
3. Stocking rates can generally be increased as a result of the increase in available feed with an increase in farm income
4. Profit margin is sensitive to quality of available feed
5. Drainage of rainfall below the root zone is reduced where perennials are grown, reducing the risk of winter waterlogging and the onset of dryland salinity.

To ensure success of perennial pastures, producers needs to be aware of their unique management requirements

Management issues affecting the introduction of perennials

For perennial species to be of commercial value, they need to persist and remain productive for at least three years. The characteristics required for persistence in perennials in medium-rainfall recharge environments are a deep-rooting habit, ability to cope with summer drought and respond to out-of-season rain. In low-rainfall environments drought tolerance including a reduction in summer activity is a priority, although recent work on Albo Tedera (*Bituminaria bituminosa var. albomarginata*) (see case study on page 29), has identified a species that remains green throughout the year, exhibiting less summer dormancy than was previously identified as a requirement.

The native legume, *Cullen australasicum*[27], also can remain green longer than lucerne, which drops its leaves more readily during the summer drought.

Both species could be using different strategies to persist in low rainfall environments and research is on-going in this area.

During former CRC Salinity's grass and legume plant evaluation programs it was found that most perennial species evaluated were not well adapted to current farming systems in southern Australia, and that new farming systems were required. Most of the perennial legume and herb species evaluated do not persist well under set-stocking[60,61]. Longevity of the pasture, production and the quality of the feed is improved by rotational grazing of perennial pastures[62]. Rotational grazing is the movement of livestock between paddocks on a regular basis with long rest periods in between. Kikuyu is the exception to this as it does persist under set-stocking and can tolerate heavy grazing.

The small seeds of many subtropical grasses can be a challenge for successful establishment

A well-managed perennial pasture under rotational grazing can increase the carrying capacity of the farm, as well as providing green feed out-of-season, reducing the need for supplementary feed during this period[61,63].

Difficulty in establishing perennials has been a major barrier to adoption. Factors affecting poor establishment include incorrect sowing depth, poor seed quality, seed dormancy mechanisms, weed control and slow germination and early growth compared with annual pasture species.

Germination and early establishment of many of the subtropical grasses and warm-season shrubs benefits from being sown during late winter–early spring as soil temperatures start to increase. Subtropical grasses require soil temperatures between 15 and 18°C[64]. However, this reduces the time between germination and the onset of summer drought, thus early vigour, particularly in relation to rooting depth, is essential for survival during summer[65]. Sowing during autumn is risky as small perennial plants struggle to compete with volunteer species during winter.

Temperate grasses and legumes are best sown during autumn two to three weeks after the break-of-season to allow weeds to germinate. These weeds can then be killed before sowing the pasture. This approach gives pasture plants time to develop a strong root system, which increases their chance of surviving the first summer[15].

The *Perennial pastures for Western Australia* publication identifies three key requirements for the successful establishment of temperate grasses[15]. These are:

- Accurate delivery rate of seed, which relates to seed size and germination percentage or seed quality
- Accurate seeding depth (accurate seed placement of 10 mm for temperate grasses is achieved using machines with independent floating tyne or disc assemblies)
- Minimal soil disturbance to reduce further weed germination and soil erosion.

The same publication lists seven key requirements for the successful establishment of subtropical grasses[64], namely:

- Total weed control during establishment
- Selecting appropriate species for the environment (soil type and climate are important, see pages 58-68 for specific species suited to each region in southern Australia)
- High-quality seed (seed quality and purity varies widely in subtropical grasses and freshly harvested seed of some species has post-harvest seed dormancy and low germination. Ensure seed is weed-free and has a known germination percentage)
- Required soil temperature and moisture as discussed above
- Sowing method, with shallow sowing at 5 to 10 mm being critical due to the small seed size of many species (for specific species details see *Perennial pastures for Western Australia*[64])
- Insect, pest and weed control after sowing
- Grazing management during the first summer. Always graze intensively for short periods so new regrowth is not grazed; a light grazing will encourage tillering; however, the time of first grazing will depend on the season and growth of the new pasture.

Germination and establishment success of salt-tolerant shrubs, such as saltbush, can be low (establishment rates of 5% are not uncommon in niche-seeded situation). Establishment rates can be increased by sowing seedlings, but this increases the cost three-fold[66]. Studies have been undertaken on the effect of light and a number of different pre-treatments[67]. However, it has been recognised that a better understanding of seed dormancy and germination requirements in species of saltbush will help to increase establishment efficiency in the field.

A project funded by MLA, AWI, LWA and FFI CRC has been initiated to develop a range of establishment methodologies for difficult to establish species such as saltbush, warm-season grasses and legumes and native pasture species.

In saline environments, salt tolerance of seedlings is useful for reliable plant establishment, but may not be as important as originally thought, as long as sowing occurs after the topsoil has been flushed of salt by winter rains[34]. In selecting sites for salt-tolerant species salinity should be measured at depths below 10 cm as there is less variation at this depth[68] and it reflects the level of salinity the plant roots would be accessing in years following establishment.

PHOTO: DAFWA

management

PHOTO: Megan Hele

Balansa clover is a productive legume on low saline, waterlogged soils

On saline land the use of mixtures of grasses, legumes and shrubs is recommended to account for landscape and seasonal variations, particularly those susceptible to waterlogging. The best combination may also include annual legumes to increase productivity and the nutritive value of the pasture.

Annual legumes that may be included in saline, waterlogged environments include balansa and Persian clover on mildly saline soils and burr medic on moderately saline soils where waterlogging is transient. There are no commercially available annual legumes suited for highly saline, waterlogged soils, but *Melilotus siculus* has shown potential for this niche during the FFI CRC field evaluation[69]. However, there are currently no specific rhizobia for *M. siculus* and so poor nodulation results in low production and sickly plants. Research within Australia is currently in progress to identify and isolate salt tolerant root nodule bacteria[70,71].

Saline and waterlogged sites may also benefit from the inclusion of halophytic shrubs as such as saltbush and bluebush. Tailored grazing management strategies are required to optimise the persistence and productivity of each of the components of the species mixture.

The final management issue in the use of perennials is their removal at the end of the perennial phase before a cropping phase. The only species for which there has been documented removal technique is lucerne[72,73] and challenges with removal at the end of the perennial phase is affecting the rate of lucerne adoption. Three methods of removal are suggested:

- **Ploughing** – which reduces the benefits of the lucerne pasture and increases the risk of soil erosion
- **Herbicide application** – has up to an 80% success rate, although success varies with time of application
- **Grazing** – requires a high stocking rate, which depends on availability of stock.

Timing of removal varies with location and cultivar, with most complete removal occurring during either the late spring or late autumn before crop establishment.

Birdsfoot trefoil has significant potential for adoption across much of southern Australia

In the pipeline technologies, path to development and commercialisation of new material

Five new or under-utilised plant pipeline technologies were identified by the FFI CRC Adoption Team based on the outcomes of the GRDC-funded National Plant Evaluation Project and included:

1. Subtropical grasses including Rhodes grass, panics, kikuyu and setaria, which can provide 20 to 30 kg of DM/ha/mm of rain during summer and early autumn. These also allow grazing on annual pastures to be deferred until the autumn break, resulting in better regeneration of annual pastures
2. Saltland legumes including fertilised balansa clover, burr medic and *Melilotus siculus*, which fix nitrogen, boosting grass production on saltland and providing a high-quality out-of-season feed
3. Chicory, a summer-active, high-quality forage for ewes and lambs, which is currently under-utilised and can reduce recharge
4. Birdsfoot trefoil, a tap-rooted perennial legume for recharge control in areas too infertile for white clover or too acidic for lucerne
5. Perennial grasses for medium- to low-rainfall environments including cocksfoot 'Kasbah', phalaris 'Atlas', fescue 'Fraydo' in southern NSW. These grasses fill the winter feed gap on properties with a large percentage of their farm under lucerne.

"The potential use of birdsfoot trefoil in Australian pastures could be far-reaching. With the development of locally-adapted varieties we now have the beginnings of a new and valuable pasture plant."

Dr John Ayres, plant breeder, NSW DPI

PHOTO: Daniel Real

Specific developments within projects of the FFI CRC that relate to the identified headline technologies include:

- Summer-dormant accessions of cocksfoot. These cultivars, which were derived from accessions collected in north Africa, were highly persistent during the four years of the CRC Salinity evaluations program at sites with less than 350 mm annual rainfall, and showed 100% persistence at Bealiba, Victoria, a slightly higher rainfall site. These accessions recorded yield scores that were on average 40% greater than 'Currie'
- Birdsfoot trefoil (*Lotus corniculatus*). Focussed breeding work on developing cultivars adapted to lower-rainfall areas is in progress in WA with several new varieties ready for release. In NSW, breeding focussed on developing varieties that are highly productive in permanent, high-rainfall pastures. To increase persistence, accessions have been selected that exhibit prolific flowering under the short day-length conditions of southern Australia's growing season. Two new varieties are ready for commercialisation. In WA, breeding has focussed on extending the range of environments where birdsfoot trefoil can be grown. The new commercially ready varieties are highly productive and hardy when grown on acidic or low fertile soils in areas receiving 500 to 1000 mm annual rainfall, particularly where winter waterlogging is an issue

"Sale of these cultivars to farmers could transform areas of land previously thought as being too difficult for a productive perennial legume."

Graeme Sandral, pasture ecologist, NSW DPI

PHOTO: Catriona Nicholls

Phalaris cultivars with increased drought resistance will provide greater options for producers in low-rainfall regions

- Phalaris cultivars with increased drought tolerance have been developed as part of a CSIRO initiative. Germplasm from north Africa has been exploited with increased levels of summer dormancy, which has already led to the release of one semi-summer-dormant cultivar, 'Atlas PG'[74] for use in the 450–500 mm annual rainfall zone. Further lines with higher levels of summer dormancy and earlier flowering should result in the release of cultivars of phalaris adapted to lower-rainfall regions (<500 mm annual rainfall).

PHOTO: Tim Prane

Promising species such as cullen australasicum *and chicory (inset) will provide greater perennial options for producers*

Ecological adaptation of plants for the low-rainfall zone of southern Australia

There is a current drive to identify perennial species adapted to the low-rainfall regions (less than 400 mm annual rainfall). Key characteristics identified as being important for their persistence include deep-rooting ability to use moisture stored in the soil profile and to help lower water tables, increased winter activity and increased summer dormancy to protect against summer drought.

The requirement for species adapted to low rainfall regions has led to plant collecting missions away from the Mediterranean Basin to areas with lower annual rainfall and increased summer drought such as north Africa and the Middle East. Recent collections have been made in low-rainfall regions of South Africa, Azerbaijan for drought and grazing tolerant wild relatives of lucerne, the United States for perennial legume species and the Canary Islands for perennial *Lotus* species and Tedera (*Bituminaria bituminosa* var *albomarginata* and var. *crassiuscula)*.

Material from earlier collections of perennial grasses in north Africa and southern Europe is being exploited for accessions with increased levels of summer dormancy in the temperate grasses. This collection of material offers real opportunities to extend the mixed farming systems of southern Australia into lower rainfall regions, offering producers in these regions productive and persistent perennial options.

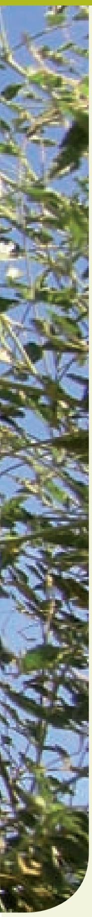


PHOTO: Richard Bennett

Species showing the greatest potential for the development of cultivars adapted to the low-rainfall regions of southern Australia include:

- **Chicory** — accessions of chicory (*Chichorum intybus*) that have been collected from relatively low-rainfall regions of the Caucasus offer significant potential to increase the drought tolerance and persistence of this species[37]. Available cultivars fit into current pasture crop rotations providing a short-term perennial forage, particularly on acid soils, with strong summer and autumn growth. However, increased summer dormancy is required for persistence in low-rainfall regions
- **Plantain** — winter-active cultivars of plantain (*Plantago lanceolata*). Cultivars of plantain included in the CRC Salinity evaluation program were summer-active. These showed strong growth during summer and autumn[29]. However, for the species to persist in low-rainfall environments increased winter activity and increased summer dormancy is required
- **Wallaby grass** — the Australian native, wallaby grass (*Austrodanthonia caespitosa*), is well adapted to the 300 to 400 mm rainfall zone. It is persistent, responds to summer rain and is thought to have a role in low input systems or those being retired from cropping in marginal environments[37]
- ***Cullen australasicum*** — the Australian native perennial legume *Cullen australasicum* is a species that may have potential in the low-rainfall zone of southern Australia, although further investigation is required before a confident assessment can be made[37]. It persisted well in the CRC Salinity evaluation program and possesses extreme drought tolerance. However, little is known about the management of this species or how it would fit into existing farming systems. Other native perennials, and in particular other species of *Cullen*, may also have potential and are being investigated

PHOTO: Daniel Real

- **Tedera** — the Canary Island endemic Tedera (*Bituminaria bituminosa* var. *albomarginata* and var. *crassiuscula*), shows extreme drought tolerance, remaining green throughout the summer months in less than 250 mm annual rainfall. It also tolerates grazing by goats in its native Canary Islands. A joint breeding program has been set up between Spain and Australia to fast-track the development of new cultivars and an understanding of management requirements for southern Australian farming systems.

Ecological adaptation of plants for saline and discharge environments

A variety of species, other than those discussed earlier, have been reported to have some salt tolerance. These species need to be investigated as they could increase the perennial options available for saline and waterlogged environments, or fit into niches where no perennial option is currently available. These species include the warm-season perennial grasses kikuyu, Rhodes grass, bambatsi panic and couch grass[39], the vegetatively propagated perennial grasses saltwater couch, marine couch, distichlis and vetiver grass for severely salinised sites[39], and the perennial herb chicory.

FFI CRC plant breeder Dr Daniel Real

Summer feed potential from perennials

FFI CRC and Department of Agriculture and Food Western Australia (DAFWA) plant breeder Dr Daniel Real's research has focussed on finding perennial legumes for the low-rainfall areas. His previous research efforts have tended to focus on annuals, due to the difficulties in finding perennial legumes other than lucerne and tagasaste, which survive over summer. However, Dr Real has found a perennial forage legume from the Canary Islands showing great promise.

Dr Real is working on two botanical varieties of *Bituminaria bituminosa* – var. *albomarginata* and var. *crassiuscula* from the Canary Islands. There is a third European variety (var. *bituminosa*) that is prohibited from introduction into Australia and is regarded as unpalatable and is biennial.

case study

Researcher – Dr Daniel Real

- Perennial legumes from the Canary Islands have the potential to provide green feed throughout summer
- Identified varieties show promise in terms of digestibility and regeneration after grazing
- Trial plantings at five sites in Western Australia have survived extreme drought conditions since 2006.

The two perennial varieties that Dr Real is investigating are considered palatable and are traditional forage for sheep and goats on the Canary Islands. The common name for them in the Canary Islands is Tedera – meaning they smell like tea.

PHOTO: DAFWA. INSET: Daniel Real

*Albo tedera (*Bituminaria bituminosa *var.* albomarginata*) at Buntine, WA*

Dr Real explained the exciting thing about these plants is their remarkable ability to maintain green foliage during summer. Trial plantings at five sites in WA survived the 2006-07 summer, which was one of the driest on record. Trial plots at Newdegate and Buntine were defoliated by locusts during November and December 2006 when they were five months old, yet by March and April 2007 they were about 300 mm tall. There was no irrigation at all to these plants.

"The plants are both drought tolerant and productive," Dr Real said. "There is less than 200 mm annual rainfall in their native area."

Grazing trials have proven the plants palatable and able to re-sprout after heavy grazing. They have 65% digestibility and 15% protein. However, researchers do not yet know whether the plants need to be spaced apart at planting or if they will be able to form a sward.

Producer experience

During a second trip to the Canary Islands, Dr Real talked to local producers who are returning to using Tedera as forage for their goats. These producers were keen to talk about the nutritional benefits of Tedera and felt their goats were healthier when fed on Tedera alone.

Dr Real also visited the Spanish breeding plots of the Murcian Institute of Agriculture (IMIDA) and a collaborative project has been set up between FFI CRC, DAFWA and IMIDA, with IMIDA providing Dr Real with germplasm and previous breeding and agronomy experience to set up a joint breeding program.

"Plant physiologists, plant ecologists, animal production researchers and many other disciplines are now involved in the Tedera research," Dr Real said.

"We have a PhD and some honours students looking at many aspects and we expect to find out a lot, quickly, to aid the breeding process and develop the agronomic package for this promising species."

Regional prospects for profitable perennials in mixed farming

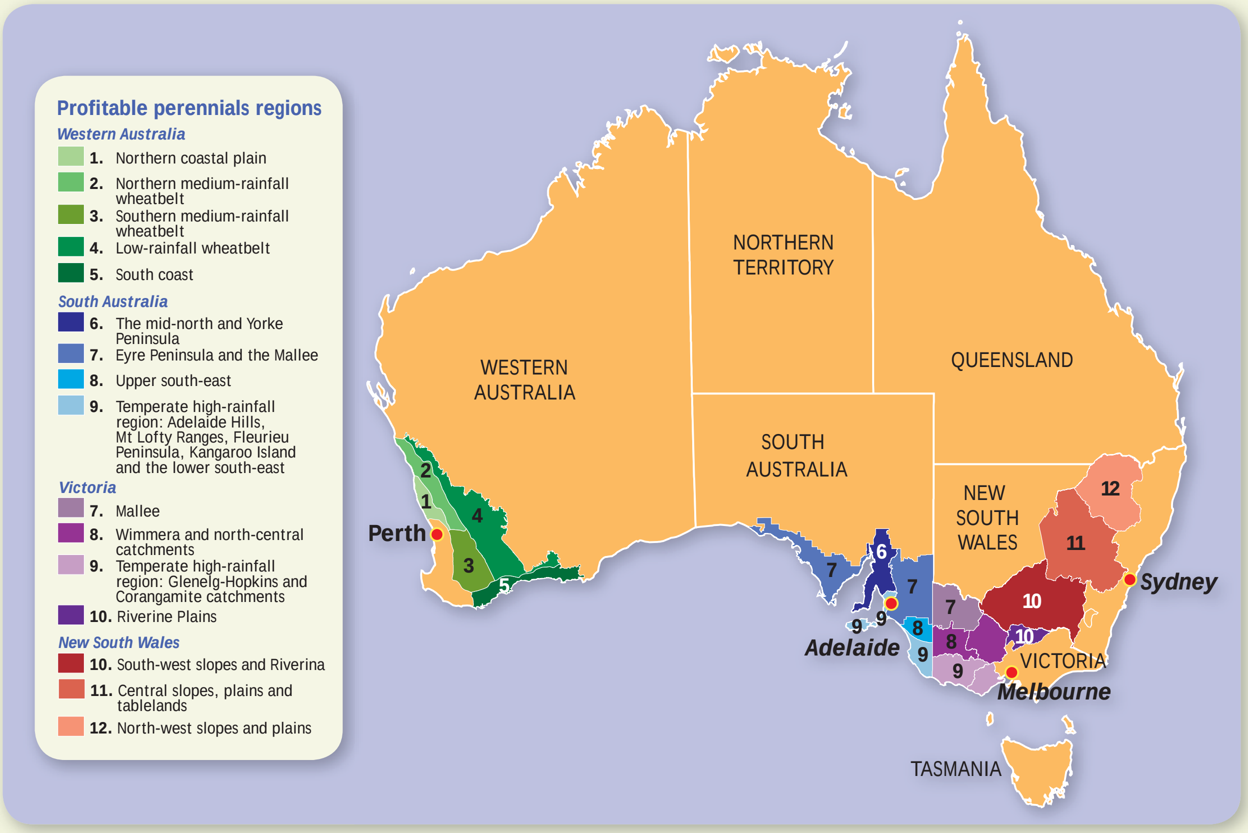
The agricultural region of southern Australia can be split into four broad agro-climatic regions:

- Temperate, cool season, wet, high rainfall (southern Victoria and NSW tablelands)
- Classic 'mediterranean' climate with cool, wet winters and warm to hot, dry summers (south-west WA and southern SA)
- Mediterranean climate with drier, cooler winters, and with more summer rain in the eastern states, than the above regions (inland south-west WA, southern SA, north-west Victoria and southern NSW)
- Temperate, sub-humid (NSW western slopes).

Within these agro-climatic regions further zonation is required to determine the perennial options available in relation to rainfall, soil type, soil pH, minimum winter temperatures and occurrence of summer rain. For the purposes of this *Prospects Statement* southern Australia has been broken down into 12 regions (see Figure 8).

Although the breakdown of the regions within each state is broadly climate-based, the climatic feature that dominates the regions varies. For example, mean annual rainfall is the dominant feature in WA and it is recognised that mean monthly temperatures will vary within each region, with temperatures being highest in the north of each region, and decrease moving south.

FIGURE 8: Regions of southern Australia for profitable perennials



regional outlook

TABLE 6: Comparison of farming systems found across regions*	LUCERNE	FODDER SHRUBS	TEMPERATE GRASSES	LUCERNE AND CHICORY	SUBTROPICAL GRASSES
(1) Northern coastal plain, WA	✓	✓		✓	✓
(2) Northern medium-rainfall wheatbelt, WA	✓	✓			✓
(3) Southern medium-rainfall wheatbelt, WA	☑		✓	✓	
(4) Low-rainfall wheatbelt, WA	✓	☑			
(5) South coast, WA	✓	✓	✓	✓	✓
(6) The mid-north and Yorke Peninsula, SA	✓	✓			
(7) Eyre Peninsula and the Mallee, SA and Mallee, Victoria	✓	✓		✓	
(8) Upper south-east, SA and Wimmera and north-central catchments, Victoria	✓		✓	☑	
(9) Temperate high-rainfall region, SA and Victoria	✓		☑	✓	
(10) Riverine Plains, Victoria and south-west slopes and Riverina, NSW	✓	✓	✓	✓	
(11) Central slopes, plains and tablelands, NSW	✓	✓	✓	✓	✓
(12) North-west slopes and plains, NSW	✓	✓		✓	☑

*✓ indicates the farming system is suitable for the region, and ☑ indicates where a case study of the farming system is included in this *Prospects Statement*

In NSW, percentage of rainfall falling during the summer months is the defining feature, with rainfall varying within each region from more than 800 mm/yr in the east to less than 500 mm/yr in the west. The regions are made up of combinations of the agricultural regions that are used by the NSW Department of Primary Industries.

In SA and Victoria, the regions are based on a combination of rainfall and soil type and have been based on the Natural Resource Management Regions in SA and the Catchment Management Authority Regions in Victoria.

To help to determine where these regions are, this publication provides an overview of each region including a detailed map.

Further detail on each of the species listed in this section can be found in *Appendix B*, along with a website reference to specific sowing and management guidelines for the species. Current recommended cultivars are included in each table and a full list of Australian registered cultivars for each species can be found at: www.pi.csiro.au/ahpc/index.htm.

High-rainfall, permanent pasture regions of southern Australia have not been included as this *Prospects Statement* is only concerned with regions of southern Australia that practise mixed farming.

The regions within each state are:

- **Western Australia** — (1) Northern coastal plain, (2) Northern medium-rainfall wheatbelt, (3) Southern medium-rainfall wheatbelt, (4) Low-rainfall wheatbelt, (5) South coast
- **South Australia** — (6) The mid-north and Yorke Peninsula, (7) Eyre Peninsula and the Mallee, (8) Upper south-east, (9) Temperate high-rainfall region: Adelaide Hills, Mt Lofty Ranges, Fleurieu Peninsula, Kangaroo Island and the lower south-east
- **Victoria** — (7) Mallee, (8) Wimmera and north-central catchments, (9) Temperate high-rainfall region: Glenelg-Hopkins and Corangamite catchments, (10) Riverine Plains
- **New South Wales** — (10) South-west slopes and Riverina, (11) Central slopes, plains and tablelands, (12) North-west slopes and plains.

Northern coastal plains, Western Australia (Zone 1)

Background

This region encompasses the northern agricultural region of WA with more than 500 mm mean annual rainfall and is composed of the West Midlands zone with small sections of the northern medium-rainfall and Central Midlands zones from *Perennial Pastures for Western Australia*[16]. It lies west of the Darling Fault line.

The region has no to low risk of frosts and cool to mild winters. Spring is mild to warm and summers are hot and dry. The predominant soil type is deep, acid sand and the main agriculture in the region is mixed sheep and cereal production.

FIGURE 9: Northern coastal plains, WA

TABLE 7: List of grasses, legumes, herbs and shrubs suited to the northern coastal plains (NCP), WA

SPECIES	DISTRICT*	ANNUAL RAINFALL	SOIL TYPE	SUITABLE CULTIVARS	COMMENTS
Grasses					
Bambatsi panic	(NCP)	>375 mm	High-fertility clay and heavy soils, pH >5.0	Bambatsi	Marginal suitability for area; summer active; good drought tolerance, some waterlogging tolerance; low frost tolerance
Consol lovegrass	NCP	>375 mm	Range of soils including deep sands, pH >4.0	Consol	Tolerant of drought and high soil aluminium (>30%); closely related to African lovegrass, a declared noxious weed
Digit grass	NCP	>450 mm	Acid sands to heavy clays, pH >4.2	Premier	Margin of suitability; good drought and aluminium tolerance; some frost tolerance; summer active
Kikuyu	NCP	>500 mm	Wide range of soil types, pH >4.0	Whittet main variety sown in WA	Niche areas only; moderately drought and frost tolerant; best on wet summer sites; good fertiliser response
Panic grasses	NCP	>500 mm	Medium to light textured soils, well-drained, pH >4.3	Gatton, Petrie	Good spring growth; frost sensitive; best grass on poor sands
Rhodes grass	NCP	>400 mm	Medium and coarse-textured soils, pH >4.3	Pioneer, Katambora, Finecut, Nemkat, Topcut, Callide	Summer active; moderately to highly drought tolerant; frost susceptible
Setaria	NCP	>500 mm	Range of soil, with good water-holding capacity, pH >5.0	Nandi, Kazungula, Narok, Solander, Splenda	Sensitive to moderately frost tolerant; good waterlogging tolerance; less drought tolerant than other subtropicals
Signal grass	(NCP)	>500 mm	Coarse-textured soils, pH >4.0	Basilisk	Moderately drought tolerant; frost sensitive
Tall wheatgrass	(NCP)	>350 mm	Saline and poorly drained soils	Tyrell, Dundas	If ungrazed develops tall, rank growth
Legumes					
Lotononis	(NCP)	>550 mm	Range, especially coarse-textured, pH >4.0	Miles, INIA Glencoe	Moderately to highly drought and waterlogging tolerant; frost sensitive
Lucerne	NCP	>325 mm	Deep, well drained soils, pH >4.8-8.0	Varieties available with varying levels of winter activity	Low tolerance to waterlogging, soil salinity and aluminium; requires soil aluminium less than 5%; good drought and frost tolerance
Siratro	(NCP)	>300 mm	Most types, well-drained, pH >4.5-8.0	Siratro, Aztec atro	Moderately to highly drought tolerant; very cold sensitive
Strawberry clover	NCP	>600 mm	Sandy-duplex and fine-textured soils, waterlogged soils, pH 4.8-8.5	Palestine, Prinsep Park, O'Connors, Grasslands Onward Grasslands Upward	Summer moist areas only; survives extreme temps from 0–35°C; tolerant of heavy grazing; low salt and drought tolerance; good frost tolerance
Herbs and shrubs					
Chicory	(NCP)	>500 mm	Free-draining deep soils, pH >4.3	Grasslands Puna, Puna II, Grouse, Forager, INIA Le Lacerta	Suitable for areas too acid for lucerne; requires some summer rain for maximum production; moderately drought and frost tolerant
Tagasaste	NCP	>325 mm	Deep sands, well-drained, pH 4.0-7.5	Cleavers Easy Graze (weeping form), commercial seed a mix of forms (out-crossing)	Drought tolerant; poor waterlogging tolerance; potential weed problem if not correctly managed

*( ) on margin of suitability for this region

Northern medium-rainfall wheatbelt, Western Australia (Zone 2)

Background

This region encompasses the northern agricultural regions of WA with a mean annual rainfall between 350 and 500 mm and is composed primarily of the northern medium-rainfall (NM) and Central Midlands (CM) perennial zones from *Perennial Pastures for Western Australia*[16].

The northern agricultural region has no to low frosts and mild winters. The Central Midlands have some frosts and cool winters. All regions have mild to warm springs and hot, dry summers with a short growing season (4–5 months).

The predominant soil type is duplex soils. Grain is the major commodity, with limited wool and prime lamb production in mixed farming systems. Beef production is starting to appear, particularly in the north.

FIGURE 10: Northern medium-rainfall wheatbelt, WA

TABLE 8: List of grasses, legumes, herbs and shrubs suited to the northern medium-rainfall wheatbelt (encompassing the northern medium-rainfall region (NM), and the Central Midlands (CM)[16], WA

SPECIES	DISTRICT*	ANNUAL RAINFALL	SOIL TYPE	SUITABLE CULTIVARS	COMMENTS
Grasses					
Bambatsi panic	NM, CM	>375 mm	High-fertility clay and heavy soils, pH >5.0	Bambatsi	Marginal suitability for area; summer active; good drought tolerance; some waterlogging tolerance; low frost tolerance
Consol lovegrass	NM, CM	>375 mm	Range of soils includes deep sands, pH >4.0	Consol	Tolerant of drought and high soil aluminium (>30%); closely related to African lovegrass, a declared noxious weed
Digit grass	(NM, CM)	>450 mm	Acid sands to heavy clays, pH >4.2	Premier	Margin of suitability; good tolerance of drought and soil aluminium; some frost tolerance; summer active
Puccinellia	CM	>350-600 mm	Waterlogged, saline soils	Menemen	Can be established where ECe >20 dS/m
Rhodes grass	NM, CM	>400 mm	Medium and coarse-textured soils, pH >4.3	Pioneer, Katambora, Finecut, Nemkat, Topcut, Callide	Summer active; moderately to highly drought tolerant; frost susceptible
Tall wheatgrass	CM, (NM)	>350 mm	Saline and poorly drained soils	Tyrell, Dundas	If ungrazed develops tall, rank growth
Legumes					
Lucerne	NM, CM	>325 mm	Deep, well drained soils, pH >4.8-8.0	Varieties available with varying levels of winter activity	Low tolerance to waterlogging, soil salinity and aluminium; requires soil aluminium less than 5%; good drought and frost tolerance
Siratro	NM	>300 mm	Most well-drained soil types, pH >4.5-8.0	Siratro, Aztec atro	Moderately to highly drought tolerant, very cold sensitive
Herbs and shrubs					
Bluebush	NM, CM	250-400 mm	Medium to fine-textured soils, pH 6.5-8.0	No commercial cultivars, distinct ecotypes present	Highly drought and frost tolerant; moderately to highly salt tolerant, low waterlogging tolerance
Saltbush	NM, CM	250-450 mm	Avoid acid sands or cracking clays, pH 4.0-8.5	No varieties released	Moderately to highly salt tolerant; moderately waterlogging tolerant; highly tolerance to drought and frost
Tagasaste	NM, (CM)	>325 mm	Deep sands, well-drained soils, pH 4.0-7.5	Cleavers Easy Graze (weeping form), commercial seed a mix of forms (out-crossing)	Drought tolerant; poor waterlogging tolerance; potential weed problem if not correctly managed

**( ) on margin of suitability for this region*

Southern medium-rainfall wheatbelt, Western Australia (Zone 3)

Background

Rainfall in this region varies from 350 to 600 mm per annum, and is composed primarily of the southern high rainfall perennial zone from *Perennial Pastures for Western Australia*[16]. Frosts are regular during the winter months, especially within the cold zone[16], where subtropical grasses show poor persistence during winter. Growing season in this region ranges from five to eight months.

Most of the area is under mixed farming (grain, wool, beef and prime lamb). Lucerne is an important perennial legume in crop rotation. Temperate grasses have greatest potential in this region.

FIGURE 11: Southern medium-rainfall wheatbelt, WA

TABLE 9: List of grasses, legumes, herbs and shrubs suited to the southern medium-rainfall wheatbelt (SMR), WA

SPECIES	DISTRICT*	ANNUAL RAINFALL	SOIL TYPE	SUITABLE CULTIVARS	COMMENTS
Grasses					
Cocksfoot	SMR	>500 mm	Well-drained duplex soils, pH >4.0	Mediterranean (moderate summer dormancy) and summer-active cultivars available	Good drought tolerance
Consol lovegrass	SMR	>375 mm	Range of soils including deep sands, pH >4.0	Consol	Tolerant of drought and high soil aluminium (>30%); closely related to African lovegrass, a declared noxious weed
Phalaris	SMR	>500 mm	Medium to fine-textured soils with high fertility, pH >4.7	Select variety on basis of requirement for summer or winter dormancy	Tolerant of waterlogging and mild salinity; summer dormant when temperature >30°C
Puccinellia	SMR	350-600 mm	Waterlogged, saline soils	Menemen	Can be established where ECe >20 dS/m
Setaria	(SMR)	>500 mm	Range of soil types with good water-holding capacity, pH >5.0	Nandi, Kazungula, Narok, Solander, Splenda	Towards margin of suitability; sensitive to moderately frost tolerant; good waterlogging tolerance; less drought tolerant than other subtropicals
Tall fescue	SMR	>500 mm	Medium to fine-textured fertile soils, pH >4.3	Summer- and winter-active varieties suitable	Tolerant of waterlogging and moderate soil salinity (<8 dS/m (ECe)
Tall wheatgrass	SMR	>350 mm	Saline and poorly-drained soils	Tyrell, Dundas	If ungrazed develops tall, rank growth
Legumes					
Lucerne	SMR	>325 mm	Deep, well drained, pH >4.8-8.0	Varieties available with varying levels of winter activity	Low tolerance to waterlogging, soil salinity and aluminium; requires soil aluminium less than 5%; good drought and frost tolerance
Strawberry clover	SMR	>600 mm	Sandy-duplex and fine-textured soils, waterlogged soils, pH 4.8-8.5	Palestine, Prinsep Park, O'Connors, Grasslands Onward Grasslands Upward	Summer moist areas only; survives extreme temps from 0-35°C; tolerant of heavy grazing; low salt and drought tolerance; frost tolerant
Sulla	SMR	>450 mm	Well-drained, medium to fine-textured, fertile soils, pH >5.0	Flamenco, Moonbi, Wilpena	Drought and frost tolerant
Herbs and shrubs					
Bluebush	SMR	250-400 mm	Medium to fine-textured soils, pH 6.5-8.0	No commercial cultivars, distinct ecotypes present	Highly drought and frost tolerant; moderately to highly salt tolerant, low waterlogging tolerance
Chicory	SMR	>500 mm	Free-draining deep soils, pH >4.3	Grasslands Puna, Puna II, Grouse, Forager, INIA Le Lacerta	Suitable for areas too acid for lucerne; requires some summer rain for maximum production; moderately drought and frost tolerant
Saltbush	SMR	250-450 mm	Avoid acid sands or cracking clays, pH 4.0-8.5	No varieties released	Moderately to highly salt tolerant; moderately tolerant to waterlogging, highly drought and frost tolerance
Tagasaste	SMR	>325 mm	Deep sandy soils, well-drained, pH 4.0-7.5	Cleavers Easy Graze (weeping form), commercial seed a mix of forms (out-crossing)	Drought tolerant; poor waterlogging tolerance; potential weed problem if not correctly managed

**( ) on margin of suitability for this region*

Think whole farm and dare to be different

Lucerne is often considered a high-rainfall plant but Jeff Patterson who had a property located east of Dumbleyung,WA, made it a successful component of his whole-farm operation despite receiving 350 mm rainfall on average a year.

When Jeff took over his property in 1990 it was a traditional wheat and sheep grazing enterprise on annual pastures, with a one-to-one rotation on the better country and one year of crop to two of pasture on the rest. Jeff tried lucerne on 120 ha around his saline areas during 1994 and it struggled. The next year was so wet Jeff had to spread urea by air, because he couldn't get onto most paddocks without bogging. But the pilot was able to land safely on his lucerne block!

"That was when the penny dropped," Jeff said. "I started seeing what lucerne could do, and the next year I planted another big block, then split the farm into eight units, four for crop and four for a lucerne phase at any one time."

Economics

Cropping is an essential part of the farming system and during 2001 Jeff started cover-cropping about 280 ha to establish lucerne after two bad years. He gained confidence from this experience and since then has continued to cover crop with lucerne most of the time.

Cost to establish is about $120–140/ha as a monoculture. When cover-cropping with barley, Jeff expects three-quarters of the yield of a monoculture crop.

key points

- The challenge is to mimic nature and work with it to maximise production profitably
- Lucerne can work anywhere you can grow wheat.

case study

farm information

- **Farmer**
  Jeff and Rochelle Patterson, Pingarning Hills, Dumbleyung
- **Location**
  300 km south-east of Perth, WA
- **Property size**
  3000 ha
- **Mean annual rainfall**
  300–375 mm
- **Soils**
  Sandy loams carrying jam, York gum and mallees
- **Perennials**
  Lucerne
- **Enterprises**
  Cropping and fine wool Merinos

PHOTO: Rochelle Patterson

Jeff Patterson with seedling lucerne under a cover crop of barley in dry conditions, 2006

PHOTO: Jeff Patterson

Lucerne with windrowed canola, 2005

case study

During 2005, a wet year, he established lucerne under canola for the first time and this gained a much better result with no loss of grain yield. Cover-cropping for the establishment year certainly helps the cash flow from those paddocks.

"During 2006, we established lucerne in a mix with annual sub-clover and balansa, which gave good production throughout the year," Jeff said.

"The deep roots of lucerne help break up the ground — a biological deep ripper — providing channels for the next wheat crop and better soil fertility.

"Even in dry seasons it gives a two bag (0.4t/ha) and 2% protein benefit."

… and management

Jeff ran about 2500 Merino ewes, 2000 hoggets and 2000 lambs at the farm's peak capacity. He doesn't spray-top to remove weeds such as ryegrass instead he uses winter cleaning. Before annual grasses set seed, Jeff puts his wethers and cull for age ewes that he is about to sell in, so they can put enough mouths onto these paddocks to effectively control the ryegrass and use less chemicals.

The rainfall on their property was outside the recommended zone, but Jeff believe you can take lucerne anywhere you can grow wheat.

"The challenge for many farmers is being prepared to change their rotations, and then facing the prospect of spending money to remove the lucerne next year," he said.

"We take the lucerne out during autumn after a good summer of grazing.

"We no longer have to resort to discs, but now manage with 2-4D and glyphosate followed by a scarifier."

What farmer wouldn't want extra out-of-season quality feed plus product diversification such as seed and hay even if livestock isn't for them. For example in January to March 2006, Jeff had 1200 ha of knee-high lucerne following heavy rain, in what had been a dry year!

"Think whole-farm, think long-term and don't be afraid to be different," Jeff said.

Low-rainfall wheatbelt, Western Australia (Zone 4)

Background

This region encompasses the low-rainfall areas of the wheatbelt (<350 mm mean annual rainfall) and is composed of the northern low rainfall and northern wheatbelt perennial zones from *Perennial Pastures for Western Australia*[16] and the low-rainfall eastern and central wheatbelt (<350 mm mean annual rainfall), which is part of the central low- to medium-rainfall and the southern low- to medium-rainfall perennial zones from *Perennial Pastures for Western Australia*[16].

There is a low incidence of frosts in the north through to some frosts in the eastern wheatbelt, with mild to cool winters. Spring is warm and summers are hot and dry with a very short growing season (<4 months) in the north.

Grain is the major commodity, with limited wool and prime lamb production in mixed farming systems. Beef production is starting to appear, in the northern wheatbelt. The central wheatbelt area has regular frosts, cool to cold winters and hot, dry summers. The growing season ranges from very short in the north-east though to short (<5 months) in the south.

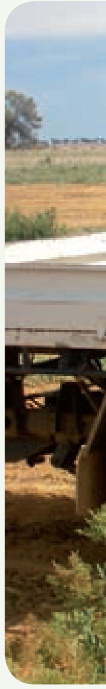
The southern-central area of this region includes part of the cold zone[16] where many subtropical grasses show poor persistence during winter. All perennial forages are at the limit of their suitability for this region and this is where new species and cultivars adapted to low-rainfall conditions are urgently required.

FIGURE 12: Low-rainfall wheatbelt, WA

TABLE 10: List of grasses, legumes, herbs and shrubs suited to the northern low-rainfall (NL), northern wheatbelt (NWh) and central low-to-medium rainfall wheatbelt (CLM), WA

SPECIES	DISTRICT*	ANNUAL RAINFALL	SOIL TYPE	SUITABLE CULTIVARS	COMMENTS
Grasses					
Puccinellia	NWh, CLM	350-600 mm	Waterlogged, saline soils	Menemen	Can be established where ECe >20 dS/m
Tall wheatgrass	NWh, CLM	>350 mm	Saline and poorly drained soils	Tyrell, Dundas	Tolerant of moderately saline soils; if ungrazed develops tall, rank growth
Legumes					
Lucerne	NL, NWh, CLM	>325 mm	Deep, well drained soils, pH >4.8-8.0	Varieties available with varying levels of winter activity	Low tolerance to waterlogging, soil salinity and aluminium; requires soil aluminium less than 5%; drought and frost tolerant
Herbs and shrubs					
Bluebush	NL, NWh, CLM	250-400 mm	Medium to fine-textured soils, pH 6.5-8.0	No commercial cultivars, distinct ecotypes present	Highly drought and frost tolerant; moderately to highly saline soils; low waterlogging tolerance
Saltbush	NL, NWh, CLM	250-450 mm	Avoid acid sands or cracking clays, pH 4.0-8.5	No varieties released	Moderately to highly salt tolerant; moderate tolerance to waterlogging; highly drought and frost tolerant
Tagasaste	NL, NWh, CLM	>325 mm	Deep sandy well-drained soils, pH 4.0-7.5	Cleavers Easy Graze (weeping form), commercial seed a mix of forms (out-crossing)	Towards margin of suitability; drought tolerant; potential weed problem if not correctly managed; poor waterlogging tolerance

**( ) on margin of suitability for this region*



Fodder shrubs fill the summer gap and keep soils under wraps

case study

A passion for running sheep, improving land sustainability and boosting biodiversity has seen Western Australian mixed cropping and sheep farmer Don Nairn trial fodder shrubs on his cereal, lupin and Merino sheep property. While the fodder shrub challenge is in its infancy, Don has been able to increase stocking rates and reduce or negate any soil erosion problems.

To improve his livestock profitability he increased the stocking rate without causing soil erosion. Don decided to change practice instead of changing the breed of sheep, converting to strip or intensive grazing. The new grazing practices were introduced during 2004, along with an automatic electric fencing system, which enabled him to erect and dismantle temporary poly-wire fences. The system fits onto their ATV and carries up to four reels of wire. Each reel holds up to 800 m of wire. The ATV mechanism is powered directly from the back tyre, with no mechanical adjustment needed. They carry plastic stakes or tread-ins on the ATV's carrier. A quick and simple system.

Strip grazing

Sowing fodder and cereal crops, then intensively grazing them at a high stocking rate has enabled Don to maintain the Merino flock and increase profitability, even through the two driest years of the farm's history. They were able to run higher numbers of stock during winter, but what about summer? Where was the feed going to come from and what was going to happen to the country with such high stocking rates?

case study

farm information

- **Farmer**
  Don Nairn
- **Location**
  East Binnu, Western Australia
- **Property size**
  2476 ha
- **Mean annual rainfall**
  320 mm
- **Soils**
  Red loam and yellow sandplain
- **Perennials**
  Fodder shrubs
- **Enterprises**
  Cereals and legumes, Merino sheep, fodder shrub plantations

PHOTO: Currie Communications

The introduction of fodder shrubs has provided a summer grazing option for Don Nairn (above) that allows high stocking rates while still protecting fragile soils from wind erosion

key points

- Increased stocking rates required a change in grazing management from set stocking to strip (intensive) grazing
- High stocking rates have increased livestock profitability
- Fodder shrubs provide a grazing solution during summer.

PHOTOS: Currie Communications

A 54-hectare Rhagodia plantation planted during 2004 on high, wind-blown country. The paddock has been heavily stocked but there is no evidence of erosion

ABOVE LEFT: Shrubs such as Rhagodia help drought-proof Don's property

"It is not practical to run a lot of stock during winter and then have to sell them during summer to a poor market," Don said.

Fodder shrubs

The solution was to introduce fodder shrubs into the farming system. Don planted shrubs on his marginal soil types, prone to wind erosion, in cells of 2000 trees in six rows. Enough room was left between each cell for fodder establishment. Guidance navigation was used to leave one, two or three passes of the seeder, depending on the soil type, between each cell. That way the sheep can be run on marginal soil and the better soils can be cropped.

Sowing the marginal land to fodder shrubs has provided a means of drought-proofing the farm and capturing out-of-season rainfall. It has allowed Don to maintain high stocking rates during summer without creating soil erosion, has reduced cost and time spent supplementary feeding during summer and autumn and provided shade and shelter for the livestock.

Lessons learnt so far

According to Don, fodder shrubs work if you like sheep and still want to protect your land. There is somewhere to put the sheep and fill the feed gap during summer and autumn.

Tagasaste, Rhagodia and saltbush are suitable but Don believes more varieties are needed and there is a need to investigate the planting of fodder shrubs by seed. There is a high cost associated with sowing seedlings across a large area. Incorporating fodder shrubs with other pastures and crops helps to restore marginal land and make the farm more profitable.

"There needs to be biodiversity on farms," Don said. "Combining plant diversity with sound grazing management and embracing the animal's capacity to seek and deal with a diverse diet, offers a good scope for moving forward."

South coast, Western Australia (Zone 5)

Background

This region encompasses the south coast perennial zone from *Perennial Pastures for Western Australia*[16] and is defined by the 350 mm mean annual rainfall isohyet to the north and the coast to the south. Mean annual rainfall ranges from 350 to >750 mm west of Albany. Frosts are infrequent, winters cool with mild springs. Summers are warm to hot with 25 to 30% of rainfall falling out of season. Growing seasons are medium to long (6–8 months).

Most of the area is under mixed farming (grain, wool, beef and prime lamb).

FIGURE 13: South coast, WA

TABLE 11: List of grasses, legumes, herbs and shrubs suited to the south coast, WA

SPECIES	DISTRICT*	ANNUAL RAINFALL	SOIL TYPE	SUITABLE CULTIVARS	COMMENTS
Grasses					
Bambatsi panic	SC	>325 mm	High-fertility clay soils, pH >5.0	Bambatsi	Towards margin of suitability; summer active; highly drought tolerant; tolerant of some waterlogging; low frost tolerance
Cocksfoot	SC	>425 mm	Well-drained duplex soils, pH >4.0	Mediterranean (moderate summer dormancy) and summer active cultivars available	Good drought tolerance
Consul lovegrass	SC	>350 mm	Range of soils including deep sands, pH >4.0	Consol	Tolerant of drought and high soil aluminium (>30%); closely related to African lovegrass, a declared noxious weed
Digit grass	SC	>400 mm	Acid sands to heavy clays, pH >4.2	Premier	Good tolerance of drought and soil aluminium; requires summer-dominant rainfall; some frost tolerance
Kikuyu	SC	>400 mm	Wide range of soil types, pH >4.0	Whittet main variety sown in WA	Niche areas only; moderately to highly drought tolerant; moderate frost tolerance; good fertiliser response
Panic grasses	SC	>500 mm	Medium textured, well-drained soils	Gatton, Petrie	Good spring growth; requires fertile soil; sensitive to frost
Paspalum	SC	>600 mm	Fertile sands to clays, pH >4.3	Common	Summer moisture; moderate drought and frost tolerance; good waterlogging tolerance
Perennial ryegrass	SC	>550 mm	Well-drained, fertile, medium to fine-textured soils, pH >4.0	Many cultivars available	>7 mth growing season; good frost tolerance; low drought, waterlogging and salinity tolerance
Phalaris	SC	>400 mm	Medium to fine-textured soils, high fertility, pH >4.7	Select variety on basis of requirement for summer or winter dormancy	Tolerant of waterlogging and mild salinity; summer dormant when temperature >30°C

*( ) on margin of suitability for this region

TABLE 11: List of grasses, legumes, herbs and shrubs suited to the south coast, WA (cont.)

SPECIES	DISTRICT*	ANNUAL RAINFALL	SOIL TYPE	SUITABLE CULTIVARS	COMMENTS
Grasses					
Puccinellia	SC	350-600 mm	Waterlogged, saline soils	Menemen	Can be established where ECe >20 dS/m
Rhodes grass	SC	>425 mm	Medium and coarse-textured soils, pH >4.3	Pioneer, Katambora, Finecut, Nemkat, Topcut, Callide	Requires summer-dominant rainfall; moderate to high drought tolerance; frost susceptible
Setaria	SC	>475 mm	Range of soil types, with good water-holding capacity, pH >5.0	Nandi, Kazungula, Narok, Solander, Splenda	Sensitive to moderately frost tolerant; good waterlogging tolerance
Signal grass	SC	>450 mm	Coarse-textured soils, pH >4.0	Basilisk	Moderately drought tolerant; frost sensitive
Tall fescue	SC	>450 mm	Medium to fine-textured fertile soils, pH >4.3	Summer and winter-active varieties suitable	Tolerant to waterlogging and moderate soil salinity (<8 dS/m (ECe)
Tall wheatgrass	SC	>350 mm	Saline and poorly drained soils	Tyrell, Dundas	If ungrazed develops tall, rank growth
Legumes					
Greater lotus	SC	>500 mm	Sandy-duplex, medium and fine-textured soils, pH >4.0	Grasslands Maku, Sharnae	High waterlogging, aluminium and frost tolerance; low drought and salinity tolerance
Lotus – Birdsfoot trefoil	SC	>500 mm	Medium-textured or sandy duplex soils, pH >4.5	Grasslands Goldie (not-well suited to WA conditions)	Moderate tolerance to drought, waterlogging and aluminium; no salt tolerance; good frost tolerance
Lucerne	SC	>325 mm	Deep, well drained soils, pH >4.8-8.0	Varieties available with varying levels of winter-activity	Low tolerance to waterlogging, soil salinity and aluminium; requires soil aluminium less than 5%; drought and frost tolerant
Siratro	(SC)	>600 mm	Most types, well-drained soils, pH >4.5-8.0	Siratro, Aztec atro	Towards margin of suitability; moderately to highly drought tolerant; very frost sensitive
Strawberry clover	SC	>500 mm	Sandy-duplex and fine-textured, waterlogged soils, pH 4.8-8.5	Palestine, Prinsep Park, O'Connors, Grasslands Onward Grasslands Upward	Summer moist areas only; survives extreme temps from 0–35°C; tolerant of heavy grazing; low salt and drought tolerance; good frost tolerance
Sulla	SC	>400 mm	Well-drained, medium to fine-textured, fertile soils, pH >5.0	Flamenco, Moonbi, Wilpena	Tolerant of drought and frost
White clover	SC	>700 mm	All except deep sands, ph >4.5-7.5	Many cultivars available	Good frost tolerance; low drought and salt tolerance; moderate waterlogging tolerance
Herbs and shrubs					
Bluebush	SC	250-400 mm	Medium to fine-textured, pH 6.5-8.0	No commercial cultivars, distinct ecotypes present	Very good drought and frost tolerance; moderately to highly salt tolerant; low waterlogging tolerance
Chicory	SC	>400 mm	Free-draining deep soils, pH >4.3	Grasslands Puna, Puna II, Grouse, Forager, INIA Le Lacerta	Suitable for areas too acid for lucerne; requires some summer rain for maximum production; moderate drought and frost tolerance
Saltbush	SC	250-450 mm	Not acid sands or cracking clays, pH 4.0-8.5	No varieties released	Moderate to highly salt tolerant; moderate tolerance to waterlogging, highly drought and frost tolerant
Tagasaste	SC	>325 mm	Deep sandy soils, well-drained, pH 4.0-7.5	Cleavers Easy Graze (weeping form), commercial seed a mix of forms (out-crossing)	Drought tolerant; poor waterlogging tolerance; potential weed problem if not correctly managed

**( ) on margin of suitability for this region*

The mid-north and Yorke Peninsula, South Australia (Zone 6)

Background

The mid-north is characterised by a series of north-south trending broad valleys floors and intervening ranges. Dominant soil types across the region are deep sands, loams and clays. The broad valley floors are commonly used for lucerne seed production, where good summer production is achieved from stored soil moisture or shallow water tables. A range of cereal, grain legume and pulse crops are grown, with annual medic or clover-based pastures, depending on soil type. The steeper ranges are non-arable. Annual rainfall varies from 400–600 mm.

The Yorke Peninsula is gently undulating to undulating land with some sand hills. It is in the 350–500 mm annual rainfall zone. Cropping (mainly barley and wheat) is the predominant land use, with grain legumes, pulse crops and some grazing of medic-based pastures also common.

FIGURE 14: The mid-north and Yorke Peninsula, SA

TABLE 12: List of grasses, legumes, herbs and shrubs suited to the mid-north (MN) and the Yorke Peninsula (YP), SA

SPECIES	DISTRICT	ANNUAL RAINFALL	SOIL TYPE	SUITABLE CULTIVARS	COMMENTS
Grasses					
Puccinellia	MN, YP	>450 mm	Waterlogged, saline soils	Menemen	Can be established where ECe >20 dS/m
Tall wheatgrass	MN, YP	>450 mm	Saline and poorly drained soils	Tyrell, Dundas	If ungrazed develops tall, rank growth
Legumes					
Lucerne	MN, YP	>400 mm	Deep, well drained soils, pH >4.8	Highly winter-active varieties (class 8-10) in 3-5 yr rotations, winter-active varieties (class 7 or less) for >600 mm rainfall and permanent pasture	Low tolerance to waterlogging, soil salinity and aluminium; requires soil aluminium less than 5%; drought and frost tolerant
Herbs and shrubs					
Saltbush	MN, YP	250–450 mm	Avoid acid sands or cracking clays, pH 4.0-8.5	No varieties released	Moderately to highly salt tolerant; moderate tolerance to waterlogging, highly tolerant to drought and frost

Eyre Peninsula and the Mallee, South Australia; Mallee, Victoria (Zone 7)

Background

The southern Eyre Peninsula includes the coastal flats with 400–500 mm annual rainfall, gently undulating land of the Wanilla Basin (450–550 mm annual rainfall) and the intervening Koppio Hills where rainfall is up to 550 mm/yr.

Most land is used for rotational cropping and grazing (mainly sheep, some beef cattle), except for the steeper slopes of the hills where land use is restricted to permanent pastures.

The northern Eyre Peninsula includes the Cleve/Mangalo Hills, and a large tract of gently undulating country with sand hills. Annual rainfall is 300–400 mm and soils are neutral to alkaline. Cereal cropping with medic-based annual pastures is the predominant land use.

The mallee region of both SA and Victoria has a mean annual rainfall of 250–350 mm and predominantly alkaline soils.

Land use is predominantly wheat-annual pasture grazing rotation with some lucerne being adopted.

All perennial forages are at the limit of their suitability for this region and this is where new species/cultivars adapted to low-rainfall conditions are urgently required.

FIGURE 15: Eyre Peninsula and the Mallee, SA; Mallee, Victoria

SPECIES	DISTRICT	ANNUAL RAINFALL	SOIL TYPE	SUITABLE CULTIVARS	COMMENTS
TABLE 13: List of grasses, legumes, herbs and shrubs suited to the Eyre Peninsula (EP) and the Mallee (M), SA and the Mallee (M), Victoria					
Grasses					
Puccinellia	EP	>450 mm	Waterlogged, saline soils	Menemen	Can be established where ECe >20 dS/m
Tall wheatgrass	EP	>450 mm	Saline and poorly-drained soils	Tyrell, Dundas	If ungrazed develops tall, rank growth; considered an environmental weed risk in Victoria
Legumes					
Lucerne	EP, M	>300 mm	Soils well drained, pH >4.8 to <8.5	Highly winter-active varieties (class 8–10) in 3–5 yr rotations, winter-active varieties (class 7 or less) for >600 mm rainfall and permanent pasture	Low tolerance to waterlogging, soil salinity and aluminium; requires soil aluminium less than 5%; drought and frost tolerant
Herbs and shrubs					
Chicory	EP	>400 mm	Free-draining deep soils, pH >4.3	Grasslands Puna, Puna II, Grouse, Forager, INIA Le Lacerta	Suitable for areas too acid for lucerne; requires some summer rain for maximum production; moderately drought and frost tolerant
Saltbush	EP	250–450 mm	Avoid acid sands or cracking clays, pH 4.0–8.5	No varieties released	Moderately to highly salt tolerant; moderately tolerant to waterlogging, highly drought and frost tolerant

The upper south-east, South Australia; Wimmera and north-central, Victoria (Zone 8)

Background

The upper south-east comprises a series of broad flats, separated by low longitudinal ranges (old coastal dunes). The soils are predominantly acidic.

Mean annual rainfall is 350–500 mm in the upper south-east and the Wimmera, rising to 800 mm in the southern highland region of the north-central Catchment Management Authority (CMA).

Sheep and beef cattle grazing perennial pastures are the main land use in the upper south-east, with some cropping on better-drained land. Grain production and mixed farming dominates land use in the Wimmera and north-central Victoria.

FIGURE 16: The upper south-east, SA; Wimmera and north-central, Victoria

TABLE 14: List of grasses, legumes, herbs and shrubs suited to the upper south-east, SA (USE), and the Wimmera (W) and north-central (NC), Victoria

SPECIES	DISTRICT	ANNUAL RAINFALL	SOIL TYPE	SUITABLE CULTIVARS	COMMENTS
Grasses					
Cocksfoot	USE, WM, NC	>450 mm	Free-draining, sandy soils, pH >4.0	Select Hispanica subspecies for low rainfall areas, intermediate types for medium rainfall areas	Tolerant of high levels of soil aluminium; Hispanica subspecies drought tolerant
Phalaris	USE, WM, NC	>450 mm	Medium to high fertility soils, pH >5.0	Select variety on basis of requirement for summer or winter dormancy	Tolerant of waterlogging and mild salinity; summer dormant when temperature >30°C
Puccinellia	USE, WM, NC	>450 mm	Waterlogged, saline soils	Menemen	Can be established where ECe >20 dS/m
Tall fescue	USE, WM, NC	>450 mm	Sandy to heavy clay soils	Select winter-active, summer-dormant varieties	Tolerant of acid soils, relatively high soil aluminium (<15%) and salinity (<8 dS/m(ECe)
Tall wheatgrass	USE, WM, NC	>450 mm	Saline and poorly-drained soils	Tyrell, Dundas	If ungrazed develops tall; rank growth; considered an environmental weed risk in Victoria
Veldt grass	USE	>450 mm	Well-drained, deep sandy soils	Mission	Moderately frost tolerant; highly drought tolerant
Legumes					
Lucerne	USE, WM, NC	>400 mm	Deep, well drained soils, pH >4.8	Winter activity (class 7) varieties in >600 mm rainfall, or permanent lucern, and highly winter active (class 10) in 400–600 mm rainfall areas and 4–6 year rotations with cereals	Low tolerance to waterlogging, soil salinity and aluminium; requires soil aluminium less than 5%; drought and frost tolerant
Herbs and shrubs					
Chicory	USE, WM, NC	>450 mm	Free-draining deep soils, pH >4.3	Grasslands Puna, Puna II, Grouse, Chico, Le Lacerta	Suitable for areas too acid for lucerne; requires some summer rain for maximum production
Plantain	USE	>450 mm		Tonic	Less drought and heat tolerant than chicory; better suited to cooler, higher-rainfall regions

Lucerne and chicory – when opposites attract

case study

To Don Price, lucerne and chicory seemed like the perfect match. A nitrogen-soaking non-legume, chicory had all the traits of being the right mate for the nitrogen-producing perennial legume, lucerne. Today, on his southern Victorian property, Don is reaping the rewards of the couple's fruitful relationship enjoying more productive pastures, less weeds and better soil structure.

"We first started to sow lucerne and chicory together about eight to nine years ago," Don said. "Today, the paddocks boasting the combination are as profitable as our cropping paddocks.

"During 2007-08 our best lucerne and chicory paddock yielded $2000 per hectare as a result of the profit derived from silage and the lambs it turned off."

A lucerne paddock that was unable to maintain pasture production was the catalyst for trialing the combination. Don decided to combine the lucerne and chicory as a possible remedy and now that paddock is probably one of his best pasture paddocks.

It is also of benefit that both species have a similar growth pattern.

Don has installed sub-surface pipes in areas normally too wet to grow lucerne. However, he is finding the lucerne is drying the soil out so much the pipes have almost nothing in them. Adjoining paddocks without lucerne and chicory still run water.

All up about 21% of the property's grazing land is sown to lucerne and chicory and Don intends to expand that amount.

case study

farm information

- **Farmer**
  Don Price
- **Location**
  Cavendish, Victoria
- **Property size**
  1000 ha
- **Mean annual rainfall**
  650 mm
- **Soils**
  Sand over clay, heavy cracking clay, redgum podzol
- **Perennials**
  Lucerne and chicory
- **Enterprises**
  Cereals, sheep (meat and wool)

PHOTO: Don Price

The combination of lucerne with chicory has proven to be a success for Don Price's lamb enterprise. Don sells heavier lambs early, leaving the following 60–70% to graze the lucerne and chicory pastures until they reach a target carcass weight of 20 kg

key points

- Lucerne and chicory work well as a mixture with complementary growth habits
- Lucerne puts nitrogen into the soil and chicory, a non-legume, uses the extra nitrogen
- A lucerne/chicory mixture supports lamb growth rates.

Local interest in Don's lucerne and chicory combination is high with a strong turnout at a recent EverGraze® *field day*

During the past, lucerne has tended to do better than the chicory. However, during 2007 the chicory did just as well, even six years after sowing.

The process

Don went on a study tour of New Zealand where producers were raving about chicory, saying it was a great tool for balancing a sheep's diet (lambs tend to do poorly on lucerne alone due to the excess ammonia it puts in the rumen). Mixing lucerne with chicory seems to solve this problem.

"We lamb during July and wean early, running weaners on a combination of clover, ryegrass and phalaris" Don said. "During that time we cut the lucerne for silage. When the initial weaning paddock has dried off, the lucerne paddock already shows signs of regrowth."

Don sells a portion of the heavier lambs early. The remaining weaners, about 60-70% of the original number, are grazed on the lucerne and chicory combination. They are weighed regularly and when they make the weight are sold. He likes to sell lambs at about 20 kilograms.

Don sells all his lambs over the hooks. They are weighed and fat scored by an agent before leaving the property. The lambs are tailored to suit a given market. For example, lambs of fat 1–2 scores are sold to Castricum Bros and the better-rounded lambs are sold to Coles. Don feels marketing is important.

"You can't just send a semi-trailer load of lambs to saleyards and hope for the best," he said.

"That's just like taking a bundle of money to the casino and hoping you will come out on top."

Weed problems solved

The combination of lucerne and chicory also helps control weeds. It tends to fill in the gaps and provides a good groundcover. Don used to spray a lot but found it was resulting in too much bare area around the plants and as a result there was too much soil movement, which left soil mounds on the lucerne. Cutting the lucerne for silage also helps with weed control.

"All-in-all, weeds just aren't a problem anymore," Don said.

Temperate high-rainfall region: Adelaide Hills, Mt Lofty Ranges, Fleurieu Peninsula, Kangaroo Island and the lower south-east, South Australia; Glenelg-Hopkins and Corangamite catchments, Victoria (Zone 9)

Background

The Adelaide Hills include undulating to steep land, mostly on the eastern side of the Mt Lofty Ranges.

Land use is mainly cattle (beef with some dairy) and sheep grazing, with limited cropping (due to steep slopes, rock and wetness). Annual rainfall varies from 400–700 mm.

Kangaroo Island is characterised by a central plateau and lower-lying land in the east. The plateau has undulating topography and is used mainly for sheep and beef cattle, grazing clover-based pastures. Annual rainfall is 550–800 mm. The lower-lying undulating land is in the 450–550 mm rainfall zone, mainly grazing, but with some cropping.

The Glenelg-Hopkins and Corangamite CMAs of Victoria have traditionally been wool and prime lamb production regions, and currently carry 11% of Australia's sheep. Cropping has been increasing in drier parts of the region, and forestry and dairying in the wetter coastal parts. Intensification of sheep properties has seen stocking rates increase by more than 50% since 1994. Mean annual rainfall is 500–800 mm.

FIGURE 17: Adelaide Hills, Mt Lofty Ranges, Fleurieu Peninsula, Kangaroo Island and the lower south-east, SA; Glenelg-Hopkins and Corangamite CMAs, Victoria

TABLE 15: List of grasses, legumes, herbs and shrubs suited to the temperate high-rainfall regions of SA and Victoria: Adelaide Hills, Mt Lofty Ranges, Fleurieu Peninsula, Kangaroo Island (KI) and the lower south-east, SA; Glenelg- Hopkins (GH) and Corangamite (C) catchments, Victoria.

SPECIES	DISTRICT	ANNUAL RAINFALL	SOIL TYPE	SUITABLE CULTIVARS	COMMENTS
Grasses					
Cocksfoot	All regions	>450 mm	pH >4.0	Select Hispanica subspecies for low rainfall areas, intermediate types for medium rainfall areas	Tolerant of high levels of soil aluminium; Hispanica subspecies drought tolerant
Kikuyu	KI	>400 mm	Wide range of soil types, pH >4.0	Whittet, Breakwell, Noonan, Crofts	Niche areas only; moderately to highly drought tolerant; moderately frost tolerant; good fertiliser response
Perennial ryegrass	GH, C	>550 mm	Well-drained, fertile, medium to fine-textured soils, pH >4.0	Many cultivars available	Greater than seven-month growing season; frost tolerant, low drought, waterlogging and salt tolerance
Phalaris	All regions	>450 mm	Medium to high fertility soils, pH >5.0	Select variety on basis of requirement for summer or winter dormancy	Tolerant of waterlogging and mild salinity; summer dormant when temperature >30°C
Puccinellia	All regions	>450 mm	Waterlogged, saline soils	Menemen	Can be established where ECe is >20 dS/m
Tall fescue	All regions	>450 mm	Sandy to heavy clay soils	Select winter-active, summer-dormant varieties	Tolerant of soil acidity, relatively high soil aluminium (<15%) and salinity (<8 dS/m(ECe)
Tall wheatgrass	All regions	>450 mm	Saline and poorly drained soils	Tyrell, Dundas	If ungrazed develops tall, rank growth; considered an environmental weed risk in Victoria
Legumes					
Lucerne	All regions	>400 mm	Deep, well drained soils, pH >4.8	Winter activity (class 7) varieties for pure stands of lucerne and semi-active (class 5) varieties for mixtures with grasses	Requires soil aluminium less than 5%; dryland and irrigated agriculture
White clover	GH, C	>700 mm	All except deep sands, ph >4.5-7.5	Many cultivars available	Frost tolerant; low drought and salt tolerance; moderate waterlogging tolerance
Herbs and shrubs					
Chicory	All regions	>450 mm	Free-draining deep soils, pH >4.3	Grasslands Puna, Puna II, Grouse	Suitable for areas too acid for lucerne; requires some summer rain for maximum production
Plantain	All regions	>450 mm		Tonic	Less drought and heat tolerant than chicory; better suited to cooler, higher-rainfall regions

Perennials a key to achieving the impossible

Wes and Margaret Seeliger have defied the 'experts' who have forecast no future for dairying in the Adelaide Hills, SA. Having retired, but still living on the farm, they have passed responsibility to the fifth generation of Seeligers — son Steven and his wife Verica.

Wes took over the farm during 1965, which had sheep, dairy, vines and poultry. Today they are dairy specialists, Wes' last major change being ironically to remove 16 ha of vines.

Dairy specialists are pasture specialists, and pasture management does not fit well with vineyard management as they both demand attention at the same time. The few thriving dairy operations remaining in the area owe their success to dedication and well-managed perennial pastures.

Wes' interest in pastures goes back to when he left school during 1954 and started his own plot trials with different species. It wasn't long before his Dad also became interested, and he was one of the first in the district to recognise the importance of soil nutrients, particularly phosphorus and molybdenum, and soil acidity. That was the start of a professional approach to pastures that continues with his sons today.

Perennials — always there

The foundation of Wes' pastures has always been the perennial grasses — mainly cocksfoot, phalaris and perennial rye — with sub-clover. SA's mediterranean climate encourages many farmers to think of a growing season that starts during April and ends in October. But every year there are summer storms, and every year the perennials respond. Annual grasses deteriorate with rain at this time.

key points

- Manage land according to its capability to give perennials their best chance
- Rotational grazing is essential for long-lasting perennial pastures
- Perennials greatly expand the growing season.

case study

farm information

- **Farmer**

  Wes and Margaret Seeliger
- **Location**

  Flaxman Valley, Barossa Ranges, South Australia
- **Property size**

  560 ha plus a further 60 ha leased
- **Mean annual rainfall**

  670-740 mm, (varying across the rain shadow)
- **Soils**

  Sandy loam over clay, pH 5-6 ($CaCl^2$) depending on where in the liming cycle
- **Perennials**

  Temperate perennial grasses
- **Enterprises**

  Westdama and Esjay Holstein Friesian stud — milking 380 head all year; 80 dry cows; 100 mated heifers; 150 yearlings; 65 calves

PHOTO: Bruce Munday

Wes Seeliger with hay cut three weeks early (on account of negligible spring rain) on land that was originally too salty to grow pasture

case study

PHOTO: Bruce Munday

Some of the Westdama herd on dryland perennial pasture in the second year of drought

"During 2006 rain in late December carried the perennials through until a big rain on the 20th of January. On the strength of this we had green feed right up until April. We didn't hand feed any dry stock during summer in a year when most graziers were feeding every week," Wes said.

Such a big rain during January is unusual, but a false autumn break is certainly not. Perennials not only insulate the Seeligers from this, they also bounce away as soon as the season does open properly. At the other end of the season, Wes often gets terrific regrowth after cutting and baling hay.

"If perennials are so good, I sometimes wonder why more people don't grow them," Wes said.

"But the reality is they are a relatively significant investment so need to be treated with care.

"A lot of farmers have spent a fair bit of money on perennials but have not much to show for the investment a few years later."

Wes learned early on that soil fertility and pH are important. Natural phosphorus levels are about 12 ppm on the property. However, they try to keep it at about 35 ppm. The pH can get down to about 5 (in $CaCl_2$) on account of the acidifying effect of the clovers, so they have to remedy that with lime about every 10 years.

Given that phalaris and cocksfoot seed can be expensive, the payback time might be several years, but they have some excellent paddocks that haven't been reseeded since the mid 1970s.

Weeds are always a threat, particularly broadleaf weeds following summer rain. Wes works on the principle that the best way to beat weeds is to crowd them out with a thick pasture. Annual grasses, such as barley grass and silver grass are gradually creeping into a couple of paddocks. Wes plans to get rid of them by spraying with paraquat during autumn at a rate that doesn't kill the perennials.

"We still have good perennial pastures that were sown 30 years ago — the secret is we have looked after them," Wes said.

Riverine Plains, Victoria, South-west slopes and Riverina, New South Wales (Zone 10)

Background

Rainfall pattern is mediterranean-like, winter-dominant and varies from 300 mm in the west of the Riverina district to 1700 mm in the southern south-west slopes, although mixed cropping stops at about 700 mm. About 25% of rain falls during the summer months in the northern plains of Victoria, increasing as you move north through NSW.

The dominate land use is mixed farming with forestry in the higher rainfall areas (800 mm). Major agricultural enterprises include those based on native and improved pasture production (beef cattle, fat lambs and wool) and occur across the entire region. Broadacre farming (winter crops), mixed farming and intensive livestock enterprises also dominate agriculture on the slopes and plains.

FIGURE 18: South-west slopes and Riverina, NSW; Riverine Plains, Victoria

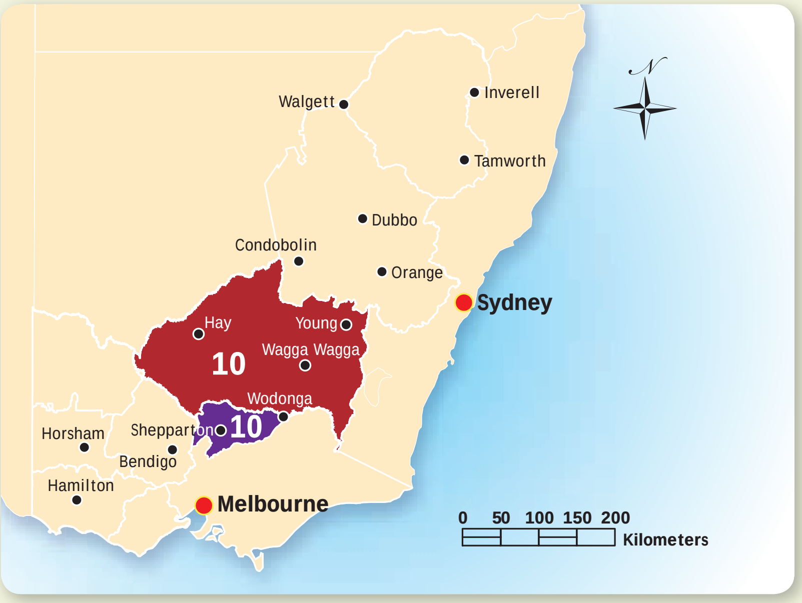


TABLE 16: List of grasses, legumes, herbs and shrubs suited to the Riverine Plains (RP), Victoria and the south-west slopes (SW-S) and Riverina (R), NSW

SPECIES	DISTRICT	ANNUAL RAINFALL	SOIL TYPE	SUITABLE CULTIVARS	COMMENTS
Grasses					
Bambatsi panic	R	>450 mm	High-fertility clay soils	Bambatsi	Summer active; tolerant of salinity and waterlogging
Cocksfoot	RP	>450 mm	pH >4.0	Select Hispanica subspecies for low-rainfall areas, intermediate types for medium-rainfall areas	Tolerant of high levels of soil aluminium, Hispanica subspecies drought tolerant
Kangaroo grass	RP				Native grass.
Perennial brome grasses	R	>600 mm	Well-drained soils, pH 4.8-7.0	Grasslands Matua, Atom, Grasslands Gala, Bareno, Exceltas	Short-lived perennial; drought and heat tolerant
Phalaris	RP, R, SW-S	>550 mm	Medium to high-fertility soils, pH >5.0	Select variety on basis of requirement for summer or winter dormancy	Tolerant of waterlogging and mild salinity; summer dormant when temperature >30°C
Puccinellia	R, SW-S	>400 mm	Waterlogged, saline soils	Menemen	Can be established where ECe is >20 dS/m
Tall fescue	R, SW-S	>500 mm	Sandy to heavy clay soils	Select winter-active, summer-dormant varieties	Tolerant of soil acidity; relatively high soil aluminium (<15%) and salinity (<8 dS/m(ECe)
Tall wheatgrass	RP, R, SW-S	>400 mm	Saline and poorly-drained soils	Tyrell, Dundas	If ungrazed develops tall, rank growth; considered an environmental weed risk in Victoria
Wallaby grass	RP	400–800 mm	Medium to heavy-textured soils	Taranna, Bunderra, Hume	Native grass; low maintenance
Legumes					
Lucerne	RP, R, SW-S	>350 mm	Deep, well-drained soils, pH >5.2	Varieties with late autumn/ winter growth	Soil aluminium less than 5%
Strawberry clover	SW-S (R: irrigated)	>600 mm	Waterlogged, alkaline soils	Palestine, Grasslands Onward, Grasslands Upward	Survives extreme temps from 0–35°C; tolerant of heavy grazing
Herbs and shrubs					
Chicory	R, SW-S	>400 mm	Free-draining deep soils, pH >4.3	Grasslands Puna, Puna II, Grouse, Grasslands Choice, Commander	Suitable for areas too acid for lucerne; requires some summer rain for maximum production
Narrow-leaf plantain	SW-S	>550 mm	Low fertility soils, pH 4.2-7.8	Lancelot, Tonic	Less heat and drought tolerant than chicory, better suited to cooler, higher-rainfall regions
Old man saltbush	R, SW-S	300 to 600 mm	Not acid sands or cracking clays	No varieties released	Salt tolerant; suitable for wheatbelt areas

Central slopes, plains and tablelands, New South Wales (Zone 11)

Background

Average annual rainfall in the Macquarie valley varies from 437 mm in Nyngan to 674 mm in Mudgee. Averages in the Lachlan vary from 425 mm in Condobolin to 867 mm in Crookwell. Broadly speaking, rain falls across the whole region evenly throughout the whole year.

Agriculture in the area is dominated by mixed farming of sheep, cattle, cereal grains and an expanding range of complementary crops including canola and grain legumes. There are also some irrigated horticultural crops including grapevines.

FIGURE 19: Central slopes and plains, NSW

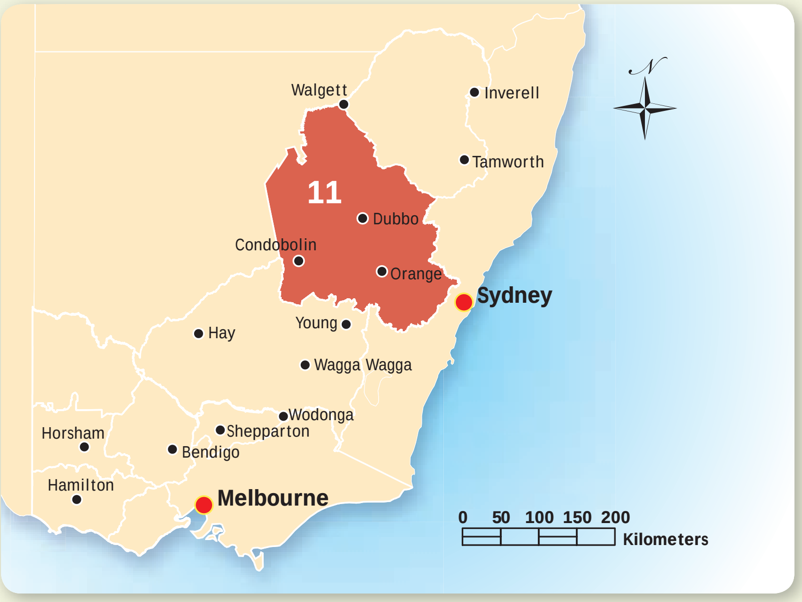


TABLE 17: List of grasses, legumes, herbs and shrubs suited to the central-west slopes (CW-S) and plains (CW-P) and central tablelands (CT), NSW

SPECIES	DISTRICT*	ANNUAL RAINFALL	SOIL TYPE	SUITABLE CULTIVARS	COMMENTS
Grasses					
Bambatsi panic	CW-P, CW-S	>450 mm	High-fertility clay soils	Bambatsi	Summer active; tolerant of salinity and waterlogging
Buffel grass	CW-P (N)	>180 mm	Light- to medium-textured soils	Biloela, Bella, Viva, Gyndah, American	Drought tolerant, rapid response to rain; requires summer-dominant rainfall
Consul lovegrass	CW-P, CW-S	>350 mm	Light sandy to loam soils, pH 4.0-6.0	Conferta	Tolerant of drought and high soil aluminium (>30%); closely related to African lovegrass, a declared noxious weed
Digit grass	CW-P (N), CW-S (N)	>400 mm	Acid sands to heavy clays	Premier	Tolerant to drought and cold; requires summer-dominant rainfall
Perennial brome grasses	CT	>700 mm	Well-drained soils, pH 4.8–7.0	Grasslands Matua, Atom, Grasslands Gala, Bareno, Exceltas	Short-lived perennial; drought and heat tolerant
Phalaris	CW-S, CT	>550 mm	Medium to high-fertility soils, pH >5.0	Select variety on basis of requirement for summer or winter dormancy	Tolerant of waterlogging and mild salinity; summer dormant when temperature >30°C
Puccinellia	CW-P, CW-S, CT	>450 mm	Waterlogged, saline soils	Menemen	Can be established where ECe >20 dS/m
Purple pigeon grass	CW-S (N)	>450 mm	Medium to high-fertility soils with medium to heavy-texture	Inverell	If ungrazed develops rank growth, requires summer-dominant rainfall
Rhodes grass	CW-P (N), CW-S (N)	>500 mm	Sandy to sandy-loam soils	Pioneer, Katambora, Finecut, Nemkat, Topcut, Callide	Requires summer-dominant rainfall, adapted to moderate acidity
Tall fescue	CT	>500 mm	Sandy to heavy clay soils	Select winter-active, summer-dormant varieties	Tolerant of soil acidity; relatively high soil aluminium (<15%) and salinity (<8 dS/m(ECe)
Tall wheatgrass	CW-P, CW-S, CT	>450 mm	Saline and poorly drained soils	Tyrell, Dundas	If ungrazed develops tall, rank growth
Legumes					
Lotus – Birdsfoot trefoil	CT	>700 mm	Diverse soil types, pH >4.7	Grasslands Goldie	Avoid high soil aluminium levels
Lucerne	CW-P, CW-S, CT	>350 mm	Deep, well-drained soils, pH >5.2	Varieties with late autumn/winter growth	Soil aluminium less than 5%
Strawberry clover	CW-S, CT	>650 mm	Waterlogged, alkaline soils	Palestine, Grasslands Onward, Grasslands Upward	Survives extreme temps from 0–35°C, tolerant of heavy grazing
Herbs and shrubs					
Chicory	CW-S, CT	>400 mm	Free-draining deep soils, pH >4.3	Grasslands Puna, Puna II, Grouse, Grasslands Choice, Commander	Suitable for areas too acid for lucerne; requires some summer rain for maximum production
Narrow-leaf plantain	CW-S, CT	>550 mm	Low fertility soils, pH 4.2–7.8	Lancelot, Tonic	Less heat and drought tolerant than chicory; better suited to cooler, higher-rainfall regions
Old man saltbush	CW-P, CW-S	300 to 600 mm	Not acid sands or cracking clays	No varieties released	Salt tolerant; suitable for wheatbelt areas

**(N) northern part of region only*

Northern slopes and plains, New South Wales (Zone 12)

Background

Northern NSW has a characteristically summer-dominant rainfall climate. Rainfall varies from less than 500 mm/yr at Walgett in the far west of the region to about 860 mm/yr at Glen Innes on the eastern tablelands. On the slopes, Tamworth averages about 670 mm/yr. Major agricultural enterprises include those based on native and improved pasture production (beef cattle, fat lambs and wool) and occur across the entire region. Broadacre farming (summer and winter crops), irrigation (lucerne through to cotton), mixed farming and intensive livestock enterprises also dominate agriculture on the slopes and plains of northern NSW.

FIGURE 20: Northern slopes and plains, NSW

TABLE 18: List of grasses, legumes, herbs and shrubs suited to the north-west slopes (NW-S) and plains (NW-P), NSW

SPECIES	DISTRICT*	ANNUAL RAINFALL	SOIL TYPE	SUITABLE CULTIVARS	COMMENTS
Grasses					
Bambatsi panic	NW-P, NW-S	>450 mm	High-fertility clay soils	Bambatsi	Summer active; tolerant of salinity and waterlogging
Blue grass (Angleton grass)	NW-P, NW-S	>600 mm	Neutral to alkaline pH, cracking clays,	Floren	Summer active; drought and flooding tolerant
Buffel grass	NW-P, NW-S(W)	>180 mm	Light- to medium-textured soils	Biloela, Bella, Viva, Gyndah, American	Drought tolerant; rapid response to rain; requires summer-dominant rainfall
Consul lovegrass	NW-P, NW-S	>400 mm	Light sandy to loam soils, pH 4.0-6.0	Conferta	Tolerant of drought and high soil aluminium (>30%); closely related to African lovegrass, a declared noxious weed
Creeping bluegrass	NW-P, NW-S	>500 mm	Medium to heavy soils	Hatch, Bisset	Requires good drainage
Digit grass	NW-P, NW-S	>400 mm	Acid sands to heavy clays	Premier	Good tolerance to drought and cold; requires summer-dominant rainfall
Forest bluegrass	NW-P, NW-S	>600 mm	Traprock soils	Swann	Requires summer-dominant rainfall; drought tolerant
Gatton panic	NW-P, NW-S	>500 mm	Medium-textured soils	Gatton	Good spring growth; requires fertile soils
Green panic	NW-P, NW-S	>500 mm	Medium-textured soils	Petrie	Good spring growth; requires fertile soils and high nitrogen levels
Phalaris	NW-P, NW-S	>550 mm	Medium to high-fertility soils, pH >5.0	Select variety on basis of requirement for summer or winter dormancy	Tolerant of waterlogging and mild salinity; summer dormant when temperature >30°C
Purple pigeon grass	NW-P, NW-S	>450 mm	Medium to high-fertility soils with medium to heavy-texture	Inverell	If ungrazed develops rank growth; requires summer-dominant rainfall
Rhodes grass	NW-P, NW-S	>500 mm	Sandy to sandy-loam soils	Pioneer, Katambora, Finecut, Nemkat, Topcut, Callide	Requires summer-dominant rainfall; adapted to moderate acidity
Legumes					
Desmanthus	NW-P, NW-S	>550 mm	Slight acidic to alkaline clays	Marc, Bayamo, Uman	Summer active; drought tolerant and deep-rooted
Lucerne	NW-P, NW-S	>400 mm	Deep, well-drained soils, pH >5.2	Varieties with late autumn/winter growth	Requires soil aluminium less than 5%
Herbs and shrubs					
Chicory	NW-P, NW-S	>400 mm	Free-draining deep soils, pH >4.3	Grasslands Puna, Puna II, Grouse, Grasslands Choice, Commander	Suitable for areas too acid for lucerne; requires some summer rain for maxium production
Old man saltbush	NS-P, NW-S	300 to 600 mm	Not acid sands or cracking clays	No varieties released	Salt tolerant; suitable for wheatbelt areas

**(W) western part of region only*

A tropical haystack

Subtropical grasses are starting to show their potential in northern NSW, where temperate perennial grasses do not persist. They have been incorporated into Denevan Ellis' livestock fattening program to close up feed gaps, reduce erosion and more efficiently harvest stored soil moisture to increase production and reduce recharge.

Subtropicals fit nicely into the hydrological system in northern NSW because soil water accumulates during their dormant winter period. The subtropical grasses then harvest stored water during their growing season during spring and summer, drying out the soil profile again.

The Ellis' sowed a 24 ha paddock during October 2006 with a subtropical grass mixture of digit 'premier', panic 'Gatton' and 'Bambatsi', and Rhodes grass 'Katambora' grass at 8 kg/ha with 60 kg/ha of starter fertiliser. No legumes were sown as there was a broadleaf weed problem.

The pasture was dry sown using a Gyral direct drill. Fertiliser was placed below the seed through the tubes with a small seed box dropping the seed onto the ground and incorporated with harrows turned upside down. Seed/soil contact was provided by a rubber tyred roller. There was not a lot of subsoil moisture but the seed germinated on 43 mm of rain received during early November. About 76 mm more rain fell between then and the end of February 2007, with the maximum fall in one day only 11 mm.

"The seedlings that emerged, survived — when these grasses germinate they are almost indestructible," Denevan said.

"Given the seasonal environment, everyone was pretty impressed, but you can always do better."

key points

- Subtropical grasses provide a living 'haystack' of dry matter
- They increase water use and control recharge
- When established they are long-lived.

case study

farm information

- **Farmer**
  Denevan and Cilla Ellis
- **Location**
  Maryvale, Duri, northern NSW
- **Property size**
  210 ha
- **Mean annual rainfall**
  675 mm
- **Soils**
  Chocolate and red basalt
- **Perennials**
  Subtropical grasses
- **Enterprises**
  Livestock fattening — prime lambs and cattle

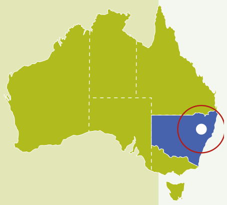


PHOTO: Sean Murphy

Lester McCormick (l), Technical Specialist (pastures), NSW DPI, and Denevan Ellis identifying the grasses for the field day participants

'Tropical grasses for the subtropics' field day at Gowrie

The biggest cost of establishment is time. Some grazing is possible during the first six months and during winter when the pasture is retarded by frost, but it might take up to three years for the pasture to thicken and come into full production.

The Ellis' property was dry matter deficient during autumn and so the subtropicals were designed to be a haystack in a paddock. It may not be the best quality, but provides the dry matter — subtropicals will outperform everything else in dry matter production. The family aims to have year-round production with a 30% mix of subtropicals, 40% lucerne and 30% crop rotation (or in fallow).

Lucerne provides quick growth and high-quality feed, which leads to fast-growing lambs, the subtropicals are there for bulk and oats/winter wheat provide high-quality winter feed and reduce the feed gap between the lucerne and the subtropicals. The subtropicals also have environmental benefits over lucerne — increased groundcover to prevent soil erosion during summer storms and cover to keep moisture at the top of the soil profile.

"I intend to add medics and clovers to the subtropicals for a nitrogen supply", Denevan said.

"I will also consider applying nitrogen on the subtropicals to increase production and improve quality — but you have to have a top quality animal production system in place to justify doing that — to convert that expense into profit."

Appendix A: Genera and species grown in field evaluations of CRC Salinity (Sub-program 5 projects)

GENUS	SPECIES	NUMBER OF LINES EVALUATED PER PROGRAM			
		DISCHARGE ENVIRONMENT	RECHARGE ENVIRONMENT	NATIVE SPECIES	LOTUS
Adesmia	*mucronata*		1		
	muricata		1		
	punctata		1		
	sp.		2		
Aeschynomene	*falcata*		1	1	
Agropyron	*cristatum*		3		
	intermedium		2		
	trichoporum		1		
Anthephora	*pubescens*		1		
Anthyllis	*vulneraria*		2	2	
Arachis	*paraguariensis*			1	
	pintoi			1	
Argyrolobium	*uniflorum*		19	16	
Astragalus	*adsurgens*		1		
	aleppicus		1		
	alopecuris		1		
	atropilosulus		1		
	cicer		2		
	crotalariae		1		
	galegiformis		1		
	glycyphyllos		1		
	monspessulanus		1		
	nothoxys		1		
	onobrychis		1		
	palaestinus		2		
	refractus		1		
	siliquosus		3		
	sinensis		1		
	sp11		1		
	sp9		1		
	speciosissimus		1		
	stipulatus		1		
	suberosus		3		
	thurberi		1		
	wootonii		1		
Austrodanthonia	*caespitosa*		1		
	fulva		1		
	richardsonii	1	3		
Bituminaria	*bituminosa*		2		
Bossiaea	*enstata*		1		
	heterophylla		1		
	walkerii		1		
Bothriochloa	*bladhii*		1		
	bladii ssp. glabra		1		
Bothriochola	*insculpta*		1		
	macra		2		
Brachiaria	*decumbens*		2		

GENUS	SPECIES	NUMBER OF LINES EVALUATED PER PROGRAM			
		DISCHARGE ENVIRONMENT	RECHARGE ENVIRONMENT	NATIVE SPECIES	LOTUS
Bromus	*araucanus*		1		
	auleticus		2		
	coloratus		1		
	inermis		7		
	mango		2		
	sitchensis		1		
	stamineus		2		
	uniloides		1		
	wildenowii		2		
	willdenowii		1		
Calotis	*erinacea*			1	
	scapigera			1	
Carpobrutus	*praecox*			2	
Cenchrus	*ciliaris*		2		
Chamaecrista	*rotundifolia*		1		
Chicorium	*intybus*		26	1	
Chloris	*gayana*		7		
	truncata x ventriculosa		1		
Chrysocephalum	*semipapposum*			1	
Convovulus	*erubescens*			2	
Coronilla	*grandiflora*		1		
	valentina		1		
	varia			30	
Crotalana	*pallida*			1	
Cullen	*australasicum*		4	4	
	cinerea		1	4	
	cinereum		2	3	
	discolor			2	
	pallidum			1	
	parvum		1	2	
	patens			1	
	tenax		4	9	
Cynodon	*dactylon*		6		
Dactylis	*glomerata*		29		
	glomerata x hispanica		4		
	marina	2	4		
Dactyloctenium	*aegyptium*		1		
Daviesia	*benthamii*			1	
	brevifolia			2	
	genistifolia			3	
	latifolia			1	
	pectinata			4	
	ulicifolia			1	
Deschampsia	*caespitosa*		1		
Desmanthus	*acuminatus*		1	1	
	virgatus		1	6	
Dichanthium	*aristatum*		2		
	sericeum		1		
Digitaria	*eriantha*		1		
	eriantha ssp. eriantha		1		
Dorycnium	*graecum*	composite of 2	2	1	
	hirsutum		10	17	
	pentaphyllum	composite of 3	7	10	
	rectum		4	7	
Eeusine	*indica*	1	5		
Ehrharta	*calcycina*		1		
Eleusine	*indica*		2		
Elymus	*angustifolius*		1		
	junceus		1		
	scaber		3		

GENUS	SPECIES	NUMBER OF LINES EVALUATED PER PROGRAM			
		DISCHARGE ENVIRONMENT	RECHARGE ENVIRONMENT	NATIVE SPECIES	LOTUS
Elytrigia	*elongata*		1		
Eragrostis	*curvula*		1		
Festuca	*arundinacea*	2	41		
	idahoensis		1		
	orthophylla		1		
	ovina		2		
	rubra		1		
Galega	*officinalis*		4	21	
	orientalis		1	26	
Glycine	*canescens*		1	2	
	falcata		1	1	
	tabacina		1	1	
Glycyrrhiza	*acanthocarpa*		1	3	
	ancanthocarpa		1		
Goodia	*lotifolia*			1	
Hardenbergia	*violacea*			1	
Hedysarum	*boutignyanum*		1		
	boutigynanum		1		
	carnosum	composite of 3	4		
	coronarium	2	7		
	fruticosum		1		
Holcus	*lanatus*		1		
Indigofera	*linnaei*			1	
	sessilifolia		1		
Kennedia	*eximia*		1		
	prorepens		1		
	prostrata		1		
Lablab	*purpureus*			1	
Leptorhynchos	*squamatus*			1	
Lespedeza	*cuneata*		6		
	juncea ssp. sericea			16	
Lolium	*perenne*	4	29		
Lothopyron	*ponticum*		2		
	ponticum ssp. elongata		1		
Lotononis	*bainesii*		5		
Lotus	*aegaeus*		1		
	arborescents				y
	arenarius		5		
	aringagensis				y
	australis		3		y
	azoricus				y
	brunneri				y
	callis-viridis				y
	campylocladus				y
	collinus		1		
	corniculatus	composite of 2,+ 1	10		
	creticus	composite of 3	4		
	cruentus		1		
	cytisoides	composite of 2	7		y
	discolor		1		
	dumetorum				y
	emeroides				y
	eriosolen				y
	gebelia		1		
	glaber		3		
	glaucus				y
	glaucus var. angustifolius				y
	halophilus		1		
	hillibrandii				y

GENUS	SPECIES	NUMBER OF LINES EVALUATED PER PROGRAM			
		DISCHARGE ENVIRONMENT	RECHARGE ENVIRONMENT	NATIVE SPECIES	LOTUS
	hispidus		1		
	jacobaeus				y
	krylovii		1		
	lancerottensis				y
	latifolius				y
	langesiliquosus				y
	macranthus				y
	maroccanus		1		
	palustris		1		
	pedunculatus		3		
	preslii		1		
	sessilifolius				y
	spartoides				y
	sp. 1		1		
	sp. 2		1		
	tenellus				y
	tenuis		6		
	uliginosus	composite of 4	6		
Macroptilium	*atropurpureum*	composite of 3, + 1	1		
Medicago	*arabica*		1		
	arborea		1		
	lupulina		2		
	marina		1		
	papillosa		1		
	polymorpha		4		
	sativa	2	85		
	sativa ssp. caerulea		7		
	sativa ssp. falcata		12		
	sativa ssp. varia		9		
	scutellata		1		
	suffruticosa		3		
Melilotus	*albus*	composite of 3	5		
	albus x polonicus			1	
	dentatus	composite of 2	1		
	elegans	composite of 3	1		
	hirsutus	1	1		
	indicus		2		
	infestus		1		
	italicus		1		
	messanensis		1		
	neopolitanus		1		
	officinalis	composite of 3	2		
	polonicus	1	3		
	sauveolens	composite of 3	1		
	speciosus		1		
	sulcatus ssp. brachystachys		2		
	sulcatus ssp. segetalis		1		
	tauricus		1		
	wolgicus	composite of 2	1		
Microlaena	*stipoides*		5		
Minuria	*leptophylla*			1	
Onobrychis	*arenaria*		3		
	armena		2		
	inermis		3		
	tanaitica		2		
	viciifolia		3		
Ononis	*cristata*			1	
	intermedia		1		

GENUS	SPECIES	NUMBER OF LINES EVALUATED PER PROGRAM			
		DISCHARGE ENVIRONMENT	RECHARGE ENVIRONMENT	NATIVE SPECIES	LOTUS
Panicum	*antidotale*		1		
	coloratum		1		
	maximum		3		
	maximum ssp. trichoglume		1		
Paspalum	*atratum*		1		
	nocorae		1		
	notatum		1		
	vaginatum		2		
Pennisetum	*clandestinum*		2		
Phalaris	*aquatica*	2	38		
	arundinacea		1		
	arundinacea x aquatica	1			
Phleum	*pratense*		3		
Plantago	*lanceolata*		4		
Psathyrostachys	*juncea*		2		
Ptilotus	*obovatus*			1	
	polyphyllus			1	
	polystachyus		3	6	
Puccinellia	*ciliata*	2	11		
	distans	1	3		
	maritima		1		
Rhynchosia	*minima*			2	
Sanguisorba	*minor*		6	5	
Secale	*montanum*		1		
Securigeria	*securidaca*		1		
	sp.		1		
	varia		6		
Senna	*artimisioides*			1	
	planitiicola			1	
Setaria	*incrassata*		1		
	sphacelata		1		
	splendida		1		
Seteria	*incrassata*		1		
Sophora	*japonica*		1		
Stylosanthes	*guianensis*		2	1	
	mexicana		1	1	
	scabra		2	2	
Sutherlandia	*microphylla*			1	
Swainsona	*beasleyana*			1	
	canescens		1	4	
	colutoides		1	1	
	cyclocarpa			1	
	formosa			1	
	galegifolia			1	
	kingii		1	2	
	paradoxa		1	1	
	perlonga		1	1	
	procumbens			1	
	pterostylis		1	2	
	purpurea		1	1	
	sp.		1		
	swainsoides		1	1	
Tephrosia	*grandiflora*		1	1	
Tetragonolobus	*maritimus*		1		
Themeda	*australis*		3		
	triandra		1		
Thinopyrum	*intermedium*		1		
	ponticum	3	4		

GENUS	SPECIES	NUMBER OF LINES EVALUATED PER PROGRAM			
		DISCHARGE ENVIRONMENT	RECHARGE ENVIRONMENT	NATIVE SPECIES	LOTUS
Trifolium	*africanum*			2	
	alexandrinum		2		
	alpestre		1		
	amabile			1	
	ambiguum		1	1	
	burchellianum		1	4	
	clusii		1		
	diffusum		2		
	fragiferum	1	9	25	
	gracilis			1	
	hybridum		7	4	
	incarnatum		1		
	isthmocarpum		2		
	lupinaster			10	
	medium			2	
	michelianum		3		
	montanum			2	
	ochroleucum		6	15	
	ornithopodioides		2		
	physodes		7	9	
	polystachyum			9	
	pratense		1	14	
	purpureum		1		
	radicosum		1		
	repens		7		
	resupinatum	3 selections	3		
	spumosum		1		
	squamosum		1		
	squarrosum		1		
	stoloniferum			1	
	subterraneum		1		
	subterraneum ssp. *yanninicum*		1		
	tomentosum		2		
	tumens		3	6	
	uniflorum		3	2	
	usambarense			1	
Trigonella	*balansae*		2		
Urochloa	*mosambicens*		1		
	mosambicensis		1		

Appendix B: Perennial species reference

Grasses

Bambatsi panic (*Panicum coloratum* var. *makarikariense*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/bambatsi-panic

Bluegrass/Angleton grass (*Dicanthium aristatum*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/bluegrass--angleton-grass

Buffell grass (*Cenchrus ciliaris*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/buffel-grass

Cocksfoot (*Dactylis glomerata*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/cocksfoot

Consol lovegrass (*Eragrostis curvula* type *Conferta*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/consol-lovegrass

Creeping bluegrass (*Bothriochloa insculpta*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/creeping-bluegrass

Digit grass (*Digitaria eriantha* ssp. *Eriantha*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/digit-grass

Forest bluegrass (*Bothriochloa bladii*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/forest-bluegrass

Gatton panic (*Panicum maximum*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/gatton-panic

Green panic (*Panicum maximum* var. *trichoglume*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/green-panic

Kangaroo grass (*Themeda australis*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/kangaroo-grass

Kikuyu (*Pennesetum clandestinum*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/kikuyu

Perennial brome grasses (*Bromus* sp.) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/perennial-brome-grasses

Perennial ryegrass (*Lolium perenne*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/perennial-ryegrass

Phalaris (*Phalaris aquatica*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/phalaris

Puccinellia (*Puccinellia ciliata*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/puccinellia

Purple pigeon grass (*Setaria incressata*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/purple-pigeon-grass

Rhodes grass (*Chloris gayana*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/rhodes-grass

Setaria (*Setaria sphacelata complex*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/setaria

Signal grass (*Urochloa decumbens*) — www.tropicalgrasslands.asn.au/pastures/signal.htm

Tall fescue (*Festuca arundinacea*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/tall-fescue

Tall wheatgrass (*Thinopyron ponticum*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/tall-wheatgrass

Veldt grass (*Ehrharta calycina*) — www.pi.csiro.au/ahpc/grasses/pdf/mission.pdf

Wallaby grass (*Austrodanthonia* sp.) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/wallaby-grass

Legumes

Cullen (*Cullen australasicum*) — www.futurefarmcrc.com.au/documents/Nativelegumesyieldwide-rangebenefits.pdf

Desmanthus (*Desmanthus* sp.) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/desmanthus

Greater lotus (*Lotus uliginosus*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/lotus---greater-lotus

Hairy canary clover (*Dorycnium hirsutum*)

Lotus/Birdsfoot trefoil (*Lotus corniculatus*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/lotus---birdsfoot-trefoil

Lotononis (*Lotononis bainesii*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/lotononis

Lucerne (*Medicago sativa*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/lucerne

Sainfoin (*Onobrychis viciifolia*) — www.pi.csiro.au/ahpc/legumes/legumes.htm

Siratro (*Macroptilium atropurpureum*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/atro

Strawberry clover (*Trifolium fragiferum*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/strawberry-clover

Sulla (*Hedysarum coronarium*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/sulla

Tedera (*Bituminaria bituminosa*) — www.futurefarmcrc.com.au/documents/Summerfeedpotentialfromperennials.pdf

White clover (*Trifolium repens*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/white-clover

Herbs and shrubs

Bluebush, small leaf (*Maireana brevifolia*) — www.saltlandgenie.org.au/resources/saltdeck.htm

Chicory (*Chicorium intybus*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/chicory

Narrow leaf plantain (*Plantago lanceolata*) — www.dpi.nsw.gov.au/agriculture/field/pastures/species-varieties/a-z/narrow-leaf-plantain

Old man saltbush (*Atriplex nummularia*) — www.saltlandgenie.org.au/solutions/ss4-saltbush-and-understorey/saltbush-and-understorey-in-a-nutshell.htm

Rhagodia (*Rhagodisa* sp.) — www.saltlandgenie.org.au/resources/saltdeck.htm

Saltbush (*Atriplex* sp.) — www.saltlandgenie.org.au/solutions/ss4-saltbush-and-understorey/saltbush-and-understorey-in-a-nutshell.htm

Tagasaste (*Chamaecytisus palmensis*) — www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/147272/tagasaste.pdf

Appendix C: Further reading and references

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