MALLEE FUTURES PROGRAM

Guidelines for Using Perennial Vegetation in the Murray Mallee

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For the Murray Mallee Local Action Planning Association Inc
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Before you start

This resource kit is intended to help facilitators, advisors, interested farmers and others to use perennial vegetation such as perennial pastures, saltbush, woodlots and revegetation using local native species, more successfully and more effectively.

The Murray Mallee Local Action Planning Association is unquestionably driven by the need to improve the sustainable management of our natural resources - including reducing saline groundwater entering the Murray River, reducing soil erosion and protection biodiversity, but is that always the case for Murray Mallee farmers? Farmers contemplating using perennial vegetation are invited to think about questions such as:

- Whether or not there is a risk of on-farm salinity as is the case for the Coorong Districts
- How much time and money might be involved
- How important it is to have a fall-back income source in 'bad times', have autumn-feed-gap and drought fodder reserves, increase carrying capacity, provide stock shelter and permanently stabilise sand dunes
- How important it is to provide habitat for wildlife, improve working conditions and improve the appeal of the property

Are there going to be 'correct answers' to the questions about the merit of each of the perennial vegetation options? Considering the spectrum of individual values, aspirations and circumstances within the region's farming community - there probably can't be.

The *Guidelines* however provide the path for a journey for personal evaluation by taking a walk through the economic factors that have a bearing on farming system long-term viability - to help work out what is 'sensible for you'. They also provide an outline of the technical factors that affect successful establishment.

They are intended to be readable either from cover-to-cover or in stand-alone sections.

What you'll find along the 'path'

The *Natural History* section provides some brief insights into the current Murray Mallee - revealing just how dynamic the region has been in relatively recent geological history and factors that affect type and distribution of native vegetation.

The *Design Principles* section provides pointers on how to optimise revegetation design for specific objectives including how to optimise:

- Shelter value
- Biodiversity value
- Returns from wood and plant products
- Fodder production
- Increase water use to reduce groundwater recharge
- The property's aesthetics

The *Establishment* section outlines the key steps required for successful projects.

The *Analysis of options* section evaluates how the benefits and costs 'stack up' financially - challenging conventional wisdom in many cases. The clear challenge is to replace the value of the agricultural production foregone from the revegetated area together with the out-of-pocket expenses with something of greater overall value.

Some other 'pointers'

The *Guidelines* are intended to be more readable than formally referenced scientific papers or consultancy reports. Some information sources are discussed in the text, but at the end of sections, you'll find briefly described references and further reading.

Some of the *Appendices* should be useful as 'ready references'.

A prior related project entitled *An evaluation of revegetation options used to reduce* recharge, along with many of the other references can be found on the appended CD-ROM.

Note that high-calibre information that is readily available is generally referred to rather than being reproduced herein.

Finally

Please note that 'revegetation with local native species' is only one of the perennial vegetation options included in these *Guidelines*.

The approach taken is to help you objectively consider 'the use of perennial vegetation' - not only from the points of view farmers, but also for those making decisions about public investment in natural resources management.

Hopefully, you will find new insights into, and heightened respect for the Murray Mallee and its occupants. May you also find inspiration about the contributions that you can make in helping to preserve regional biodiversity and to develop more sustainable farming systems.

Acknowledgements

Thanks to:

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Photos are taken by Peter Bulman unless indicated otherwise.

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Disclaimer

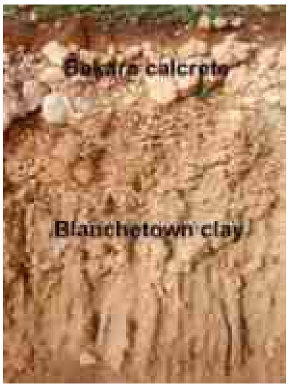
Contents

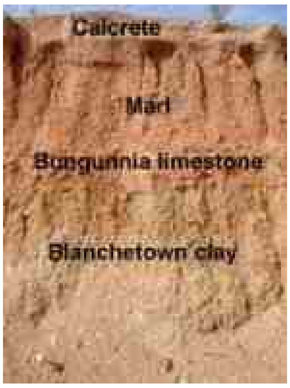
This section endeavours to provide a concise and insightful integrated overview of the region's geology, soils and matching native vegetation. It should provide an appreciation of how dynamic (as opposed to static) that the region has been (and still is) and provides more detailed sources of information.

It also highlights aspects of natural history that influence the prospects of successful revegetation.

Geology-soils interactions

Looking at how well adapted the vegetation is to the current environment suggests that the native vegetation has been this way for eons, but not so. Less than 10,000 years ago the mallee was subject to a climate change that had sand blowing all over the Murray Mallee - the red (Bunyip) sands to the north and paler (Molineaux) sands to the south. These are the same soils that tend to readily mobilise again (erode) when cultivated or over-grazed. They are coarse textured - lacking the finer loam and clay particles needed to improve moisture holding capacity, and are also low in organic matter and nutrients. These factors in conjunction with inherent susceptibility to wind erosion make such deep sands difficult to revegetate.





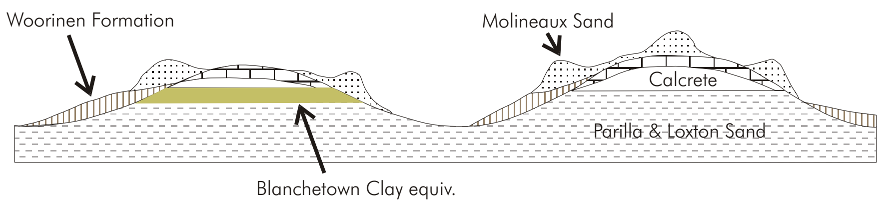
As described later, the degree of calcreting of the lime layers due to the wetting and drying cycles significantly affects land capability and prospects for successful revegetation. Also the influence of Blanchetown Clay accounts for more of the patchy crop yields and the revegetation failures than it is probably given credit for.

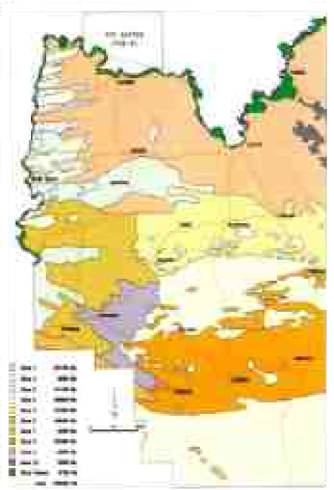
Considering that there seems to be so little evidence of young mallee eucalypt seedlings in remnant native vegetation and that mallee eucalypts are bound to easily live for more than a century, there must have been far fewer than 100 generations since the last major climate change. That is like 'yesterday' relative to:

- 40-7 million years ago when the region was under the sea and beds of fossiliferous limestone 190500m thick were deposited (Tertiary: Mannum Formation)
- 7-1.5 million years ago when shallow marine and coastal sands were deposited 'when the tide was well and truly in' (Tertiary: Loxton Sand, Parilla Sand and North West Formation)
- 1 million years to 10,000 years ago when sodic clay deposits (Blanchetown Clay) were followed by limestone deposits (Quaternary: Bungunnia Limestone) when the region was a vast freshwater lake or series of lakes and then aeolian lime was deposited (Quaternary: Bakara and subsequently the Woorinen Formations)

The periodic erosion and redeposition of this lime during relatively recent arid periods was what gave rise to the Bunyip and Molineaux sands!

Example of Kunlara system (after McCord)





Land zones from the District Soil Conservation Plan (see Appendices)

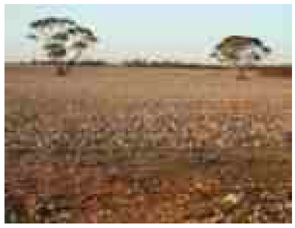
Two excellent geologically based surveys describe the land units and soil profiles for the northern and southern Murray Mallee - the sources of the geological outline above. At the risk of oversimplification, for our intents and purposes most of the land units have the following soil profiles and land capability classes in common:

- Deep sands >1.5m deep (Bunyip and Molineux sands) - mostly land capability classes IV & VII pending dune height (some use a dune height of 5m and others use 9m as the criterion to determine which class applies)
- Sand spreads < 1.5m deep including loamy sands over heavier textured soils with or without bands of lime/limestone mostly land capability class III
- Heavier textured flats with loams or clays at <0.3m - mostly land capability classes II & III
- Shallow loams over limestone that is calcreted to varying degrees - mostly land capability class II

Deep sands

Sand spreads

Heavier textured flats



Shallow stony loams

Soil texture and land capability

Managing land according to its capability - 'the ability of land to support a type and intensity of use (or management) on a sustained basis without being degraded' - provides the means for reducing excessive wind erosion and groundwater recharge. The key is maintaining an adequate level of surface cover.

Land capability class	Description of land	Approx area (%)	Typical examples of soil type and topography	Minium surface cover level* (%)
I	Low potential for wind erosion	Minimal	-	-
IIa	Low to moderate potential for wind erosion	39%	Sandy loam to loam soils on flats/slopes	20%
IIIa	Moderate potential for wind erosion	14%	Sandy soils on flats/slopes	50%
IVa	Moderate to high potential for wind erosion	40%	Low sand dunes (<5m)	>70%
VIIa	Very high potential for wind erosion	7%	High sand dunes (>5m)	Perennial vegetation necessary

* *See Assessing ground cover on page 65.*

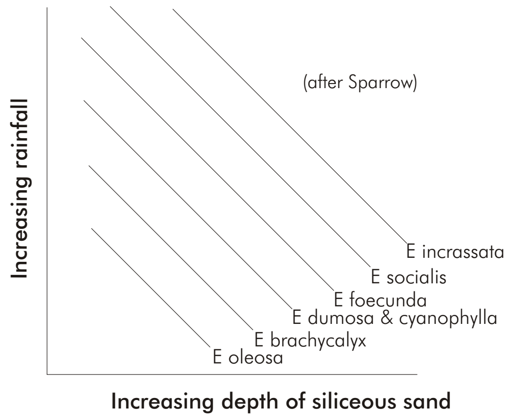
Soils-vegetation-climate interactions

Most people driving through the mallee only see a monotonous drabness; the more observant will see a subtle diversity of foliage with different species flowering at different times of the year. Walking into and identifying species present in patches of mallee (see page 67) however, seems to reveal a haphazard occurrence of different species with no strong pattern. Some mallees such as ridge-fruited mallee (*Eucalyptus incrassata*) range from deep sands to soils over shallow saline water tables; red mallees (*Eucalyptus oleosa* and *socialis*) and can be found on a wide variety of soils with just about any other mallee - including the arid extremes of mallee occurrence.

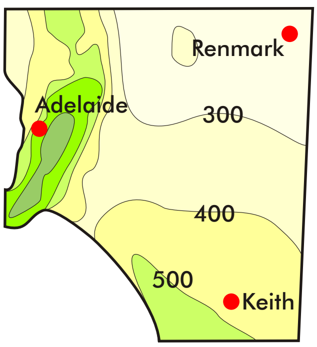
In other regions, the dominant tree species and mature heights 'tell' a compelling 'story' about the moisture availability (rainfall + soil depth and texture), fertility and drainage - without even doing a soil profile.

There doesn't seem to be quite such a useful story to be told in the mallee, but apparently there are still subtle patterns of distribution based on moisture availability - an interaction between rainfall and soil moisture holding capacity. Extra soil depth compensates for decreasing rainfall. Validating this might involve keeping an eye out to see if *E socialis* and *E incrassata* are indeed restricted to the deeper soil profiles in the more arid northern Murray Mallee.

Relationship between rainfall and soil depth for some mallee species



Climate



Rainfall ranges from 400mm per annum in the south down to 250mm per annum in the north - with one-in-five year droughts expected in the northern areas.

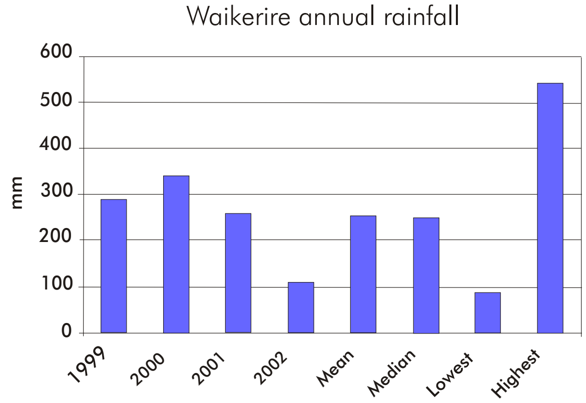
Revegetation projects need to contend with:

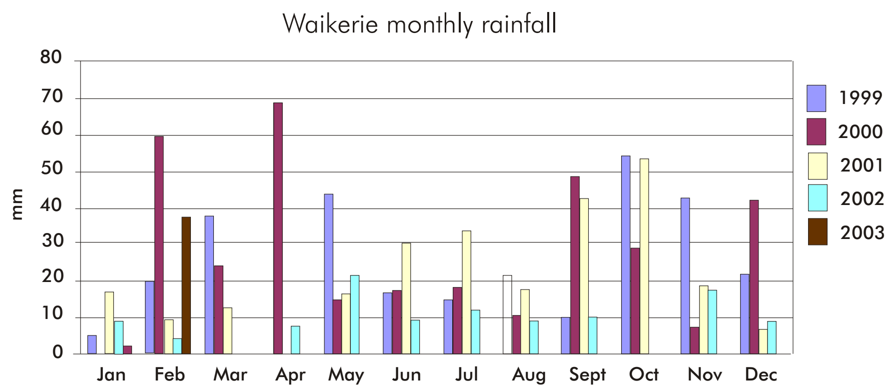
- Frosts occurring from July to September
- Strong winds swinging from the NW to SW from July onwards
- Hot northerlies from September through summer

One advantage for the more arid northern Murray Mallee is that red-legged earth mite (RLEM) does not seem to devastate young germinants, either at all or as often as is the case in the southern Murray Mallee.

Average rainfall may be a major limiting factor, but the **actual seasonal falls** and **distribution pattern of rainfall events** during the establishment year can really 'make or break' a revegetation project (and farm income) in any given year.

Data for Waikerie illustrating the variability between and within seasons

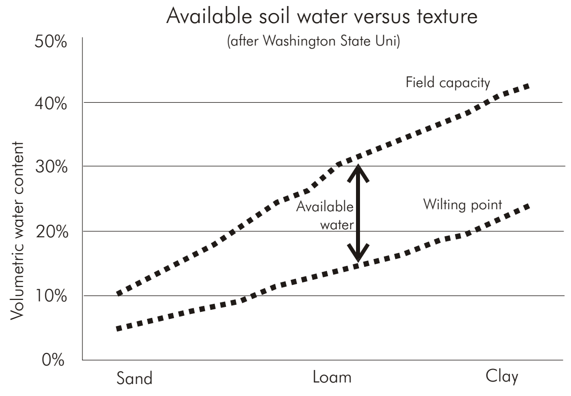


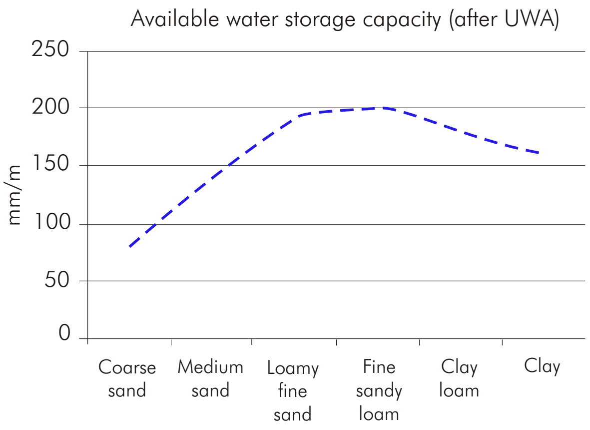


Receiving the rainfall is one thing, having a soil profile with the capacity to store it is another. The depth of soil able to be explored by plant roots and the soil texture(s) in the profile provide the basis to calculate storage capacity.

Soil water relationships

Another major site factor that affects the success of direct seeding is the rate at which the topsoil dries out. The easily erodible deep sandy profiles dry out in the 'germination zone' much more rapidly than loams and clays. This is not to say that clays don't have their own problems - clays may hold more water but take longer to wet, are harder to extract water from, and can inhibit root exploration.





The following examples of estimating soil moisture storage illustrate how increasing soil profile depth can offset poor moisture storage capacity of coarse-textured sands.

An available water volumetric water content of 8% equates to 80mm of water per metre depth of soil. So a 5m **deep coarse-textured sandy profile** might be capable of holding 400L/m^2. **Loamy topsoils** of the flats might hold 200mm/m, with a 0.5m profile holding 100L/m^2 - thus requiring approximately another 2.5 m of clay or marl as sub-soil to be equivalent to a deep dune.

The capacity for **sand spreads** and **shallow stony soils** to support deep-rooted perennial vegetation depends almost entirely on them having deeper subsoils that can be accessed by plant roots ie are not impeded by unbroken calcrete or other hardpans. A 0.8m deep profile of loamy sand can only be expected to hold approximately 120mm or 120L/m^2 (probably enough for survival over the first summer though) and the storage capacity of 15cm of loam over calcrete doesn't even warrant calculating.

Loss of moisture through evaporation from the soil surface must be high with the light rainfall events typical of the Murray Mallee. If half the annual rainfall found its way into the profile (~125L/m^2), that is likely to be more than enough for survival over the first summer (also see the sections on weed control and watering in the *Establishment* section).

Chemical and physical constraints such as hardpans, salt and boron can also significantly limit plant development.

Climate-vegetation interactions

The impressive response of vegetation to relatively 'recent' **climate change** is also worthy of reflection.

During more humid times, it is mind boggling to contemplate the prior widespread distribution of species such as the mighty sugar gum (*Eucalyptus cladocalyx*) which has contracted to minor occurrences in three disparate locations - Eyre Peninsula, the Mid North and Kangaroo Island. Red stringybark (*Eucalyptus macrorhyncha*) near Clare and southern blue gum (*Eucalyptus bicostata* closely related to Tasmanian blue gum) near Burra must have occurred contiguously across south-eastern Australia because their *nearest* populations are in central Victoria. Relicts of snow gum (*E pauciflora*) can even be found in the South East region of South Australia too.

Small fragmented areas of remnant native vegetation are likely to be more prone to in-breeding than larger areas. Considering this factor and the need for a broader genetic base with which to cope with future environmental changes, it makes sense to collect seed from a broad range of large populations occurring in roughly comparable or even drier site conditions - as embodied in the *NatureLinks* philosophy outlined on page 17.

Such an approach questions the wisdom of guidelines which advocate collecting seed within a stone's throw from the site to be revegetated.

It may be largely academic, but it follows that it is desirable to establish as wide a selection of site-suitable species that is practically possible to enable a 'survival of the fittest' selection process.

For example, manipulating river pool levels via the locks and irrigation has caused flood plain salinisation. Had a similar change occurred naturally over time, it is easy to picture progressive colonisation of such sites by well-suited species such as *Melaleuca halmaturorum* that is currently largely restricted to coastal environments.

The appended species list on page 70 summarises a range of species suitable for the three key zones - Northern, Central and Southern. It includes an interpretation of species suitability according to soil type.

The *Native vegetation of the Murray region of South Australia* CD-ROM provides an excellent guide to the identification and restoration of **vegetation communities**. It is based on an interpretation of comprehensive biological survey data and includes the natural distribution, photos and associated species. **Propagation information** and natural distribution information are also well presented along with photos for a more comprehensive **list of species**.

What seed is that? is another useful source for seed collection hints and propagation advice.

The table on page 7 indicates the soils and sub-regions that favour the different communities.

Common vegetation communities for mainly the central and northern Mallee Murray

N = Northern; C = Central, and S = Southern as per map on page 70

Dominant species describing vegetation communities	Deep sands	Sand spreads loamy sands	loams & clays	Shallow loams	Calcrete & comments
Woodland					
Black oak (*Casuarina pauper*)	N	N	N		None; prefers deep sandy loams
Native pine (*Callitris gracilis* syn *preisssii*)	S	S	S	S	Generally broken, but none to sheet
Mallee box (*Eucalyptus porosa*)		S	S	S	Generally none, but sometimes sheet and broken
Mallee					
White mallee (*E dumosa* +/- *leptophylla*)	N & C	N & C	N & C		None
Slender-leaved & red mallee (*E leptophylla* & *socialis*)	N,C & S	N,C & S			None to broken
Blue-leaved mallee (*E cyanophylla* +/- *socialis*)	N	N			None
Square-fruited mallee (*E calycogona* & *dumosa*)		N,C & S	N,C & S		None
Yorrell (*E gracilis* & *oleosa*)			N & C	N & C	Generally broken, but none to sheet
Yellow mallee (*E incrassata* & *Leptospermum coriaceum*)	S	S	S		Broken & also occurring on dunes
Shrublands					
Dwarf oak-bush (*Allocasuarina pusilla* & *Leptospermum coriaceum*)	S				None
Narrow-leaf Hop-bush Low shrubland (*Dodonaea viscosa angustissima*)		N		N	Generally broken, but none to sheet; colonises cleared land
Warty native pine (*Callitris verrucosa*)	N,C & S	N,C & S			None
Dryland tea-tree & mallee honey myrtle (*Melalueca acuminata* & *M lanceolata* +/- *E socialis* +/- *E leptophylla*)		S	S		None to broken
Bullock bush (*Alectryon oleifolius*)			N	N	Broken
Spine bush (*Acacia nyssophylla*)		N?	N	N	Broken
Chenopod shrublands					
Ruby salt bush (*Enchylaena tomentosa*)			N,C & S	N,C & S	Broken
Bluebush (*Maireana sedifolia*)		N	N	N	None to broken
Black bluebush (*Maireana pyramidata*)			N	N	Broken
Grasslands					
Spear grass (*Stipa* sp)		N	N		None or broken
Sword sedge, scented mat rush, Spear grass (*Lepidosperma* sp, *Lomandra effusa*, *Stipa* sp)			S	S	Broken

Species selection for projects

The full-scale map of the one illustrated on the right is included in these *Guidelines* and is intended to help determine which vegetation community(ies) occurred on a prospective revegetation project site prior to clearance. The key is however somewhat difficult to use with so many similar colours, but cutting the key off the map helps with colour matching.

The main species associated with the vegetation communities are included in the *Native vegetation of the Murray Region of South Australia* CD-ROM. Just select your region and then the appropriate vegetation community.

Another way to compile a more comprehensive species list for a revegetation project is select species from the table on page 70 according to the sub-region and soil type.

This species list is also included as a spreadsheet 'data base' (*Species.xls*) on the appended CD-ROM and can be used to generate species lists for projects according to soil type and sub-region.

Florlist is valued by those who already have a good knowledge of the region's flora. Available from the Department of Environment and Heritage, the database generates 'raw' species lists based on location but does not include plant descriptions or other information.

Further reading

Berkinshaw T 2003 *Native Vegetation of the Murray Region South Australia*, CD ROM produced for the Mid Murray Local Action Planning Association by Greening Australia (SA) Inc; a copy of the CD ROM can be borrowed from the Murray Mallee Local Action Planning Association Inc to assist with the planning of local native species projects (08 8531 2066 or mmlap@lm.net.au) or a copy can be purchased from the Mid Murray Local Action Planning Association for $25 (088564 5002 or midlap@lm.net.au)

Bonney N 2003 *What seed is that?* Neville Bonney ISBN 0 646 19820 3 - well illustrated with a useful profile for 280 South Australian species including photos, seed collection and propagation hints; contact Neville nbonney@senet.com.au to obtain a hard copy for $68.50 or CD-ROM

Boomsma CD 1981 *Native trees of South Australia* South Australian Woods and Forests Department, Bulletin 19 - includes illustrations used in this document, descriptions of wood attributes and honey production but is out of print and may only be located in some agency office libraries

Costermans L 1983 *Native trees and shrubs of south-eastern Australia* Weldon Publishing, Sydney - excellent comprehensive well-illustrated reference for more than the Murray Mallee; try Adelaide Botanic Gardens bookshop

Cunningham GM et al (unsure of date) *Plants of western NSW* - a revised edition of this highly valued reference is stocked by the Botanic Gardens and possibly other bookstores for approximately $264

Foulkes JN and Gillen JS (Eds.) 2000 *A biological survey of the Murray Mallee, South Australia* Department of Environment, Heritage and Aboriginal Affairs, South Australia ISBN 0 7308 5872 0 - identifies 57 floristic vegetation groups based on dominant species from baseline biological data from an extensive survey with 35 mapped groups occurring in South Australia; lists associated species; shows locations and describes land form, (top) soil texture, calcrete characteristics and rainfall, but does not lend itself to easily constructing revegetation species lists for different site types; lists 15 threatened plant species; includes a map of the remnant vegetation, but is not that easy to interpret using the key; mainly for the devotees and is available from the Department of Environment and Heritage, Keswick for $38.50

Kahrimanis MJ and Carruthers S 2001 *Biodiversity plan for the South Australian Murray-Darling Basin* - identifies key biodiversity and special habitat areas, threatened species, major threats and actions to reduce threats; from Department of Environment and Heritage, Keswick as a glossy summary or full report

McCord AK (undated) *A description of land in the southern Mallee of South Australia* Primary Industries, SA
- provides excellent detail on the geology and soil profiles, but misses a small strip just east of the river; should be available from PIRSA and is available on a CD ROM *Murraylands land resource information* and *Soil data sheets* available from DWLBC, Soil and Land Information Unit, Waite (08 8303 9316 or Email hall.james@saugov.sa.gov.au)

MMLAP 2003 *An evaluation of revegetation options used to reduce recharge* A report prepared by Farm Tree Systems for the Murray Mallee Local Action Planning Association - provides a more detailed synthesis of the region's soils and hydro-geology and the results of investigations into the factors affecting the success or failure of revegetating with lucerne, saltbush and local native species; accessible on the CD-ROM in the 'Guidelines' and from http://lm.net.au/~murraymalleelap/

Murray Mallee District Soil Conservation Board 2000 *District (Soil Conservation) Plan* Produced in 1992 and revised in 2000 with the support of Primary Industries and Resources SA and the Soil Conservation Council - outlines the district's land zones and appropriate land use management practices; see *MM Soil Con Board District Plan.pdf* on the enclosed CD-ROM

Nicolle D 1997 *Eucalypts of South Australia* Dean Nicolle, Morphett Vale SA - well-illustrated 208p A5 glossy colour book; try Adelaide Botanic Gardens bookshop or contact Dean on 8387 3656

Potter JS, Wetherby KG and Chittleborough DJ 1973 *A description of the land in County Albert, County Alfred and part of County Eyre, South Australia* Department of Agriculture, SA, Soil Conservation Branch, LD 1 - covers the geology and soils of the northern Murray Mallee but out of print but is available on a CD ROM *Murraylands land resource information* and *Soil data sheets* available from DWLBC, Soil and Land Information Unit, Waite (08 8303 9316 or Email hall.james@saugov.sa.gov.au)

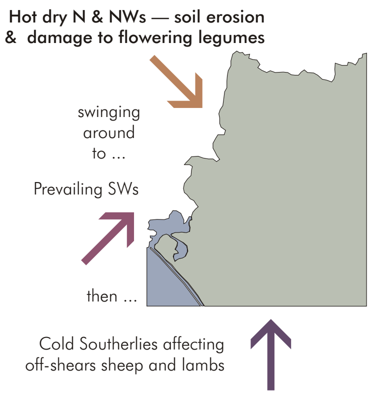
Sparrow AD 1991 *A geobotanical study of the remnant natural vegetation of temperate South Australia* A thesis submitted to the University of Adelaide for a degree in Doctor of Philosophy - the thesis probably includes the reference to the book containing the graphic entitled *Relationships between rainfall and soil depth for some mallee species*; the table of contents and the abstract are on the CD-ROM

Revegetation planning and design should be done in conjunction with property management planning. Land capability assessment (see pages 2 and 64) provides the foundation for property management planning the basis for any redesign of paddock boundaries that are fundamental to any revegetation planning and management of soil erosion (see *Soil conservation* on page 64).

The following steps can be useful:

1. Prepare a property base plan ↓	Use plastic overlay sheets on an aerial photo to draw soil boundaries/land capability classes; existing developments; remnant native vegetation; any weed problems and prevailing wind direction.
2. Write down long-term goals ↓	Relevant factors include: current and future dependence on on-farm income and financial needs including succession planning; priorities for on-farm labour/time; property working environment and capital value; need for shelter; the need to soak up seepage; and importance of providing wildlife habitat.
3. Design the revegetation according to the goals ↓	The *Design Principles* outlined below highlight differences in terms of: cost of establishment; value of displaced agriculture; returns from wood and plant products; value of shelter provided and fodder produced; waiting time for returns; property capital value; and value for wildlife habitat.
4. Evaluate the costs and benefits and reflect on the goals ↓	This is a vital step in making an informed decision about what revegetation to tackle, if any, and why. For example, for firewood, brush, fodder, shelter or whatever, an appreciation of the relative costs, returns and time frames provides the basis for reflecting on the relative merit of allocating money and time (on-farm labour) for different revegetation options.
5. Modify the designs accordingly and implement the plan in stages ↓	One way of evaluating and modifying the designs is to 'rough up' the costs and benefits for different designs on a ***whole-of-farm scale*** - there is no way that the differences between designs can be ignored. Taking 'bite-size' steps is an achievable way see the plan become a reality.

Design Principles incorporates sections with pointers on how to optimise revegetation design for specific objectives including shelter, biodiversity, wood and plant products, fodder, increasing water use ie reducing groundwater recharge and aesthetics.



Shelter principles

This section reflects on the winds that are damaging for crops and stock, discusses how to optimise the location and orientation of shelterbelts and summarises recently measured yield responses to shelter.

The most damaging winds in terms of soil erosion and emerging crops are the pre-frontal north-westerlies and ensuing south-westerlies. Also, hot dry northerlies and north-westerlies can damage legume crops at time of flowering. Belts orientated north-south provide some protection from both north-westerlies and south-westerlies and there is no winter shading of crops and pastures as can happen with east-west orientated belts that have tall trees in the southern row.

The cold persistent southerlies that follow a change are more of a problem for new-born lambs and off-shears sheep. In which case, combining stock emergency shelter and autumn feed gap fodder blocks on less productive land makes a lot of sense. Another option is to have dedicated smaller paddocks with perimeter belts on all sides for stock protection - possibly near the shearing shed.

Although, paddocks are almost invariably too large to be significantly protected by perimeter plantings, the production and protection benefits (see box) of alley systems need to outweigh the value of the displaced agriculture. Think of a 64ha paddock 800m by 800m with a 8m-tall shelter belt along one fence. When the wind is blowing perpendicularly to the shelterbelt, the 'quiet zone' might still only be the width of 10 times the tree height (10H), that is 80m or 10% of the paddock. The lower the rainfall, the larger the paddocks become, the shorter the slower windbreaks grow and the lesser the proportion of the paddock sheltered.

Graphical depiction of realistic sheltered area to scale for 800m paddock and 8m-high shelterbelt

Note that the taller growth comes at the expense of greater competition (allelopathy). This is not good in terms of competition with agriculture, but can be beneficial as a firebreak or for control of noxious weeds.

Local native species lists are provided on page 70, but the extra height needed to increase the sheltered area can be achieved by using taller-growing species from the Western Australian wheatbelt in conjunction with local mallees and mid- and understorey species. Taller species include:

- Dundas mahogany (*E brockwayi*) which may not be that durable but is relatively quickly growing and well-suited to arid limestone soils and sandy loams
- Dundas blackbutt (*E dundasii*) which has durable timber and is suited to sandy loams
- Salmon gum (*E salmonophloia*) which has durable timber and is suited for heavier textured soils

Sugar gum (*E cladocalyx*) can be quick growing where there is lots of growing space and/or water run-on in the southern Murray Mallee but is prone to dying back when mature and iron deficiency in calcareous soils is common and indicated by yellow leaves.

Locating belts high in the landscape is normally desirable, but planting just on sand dune crests invites erosion on areas bared by tree roots. Planting the whole of the dune is primarily a consideration for permanent productive stabilization rather than for shelter. This is because some of the wind needs to pass through the belt to provide significant shelter, rather than to be deflected over somewhat impenetrable block plantings.

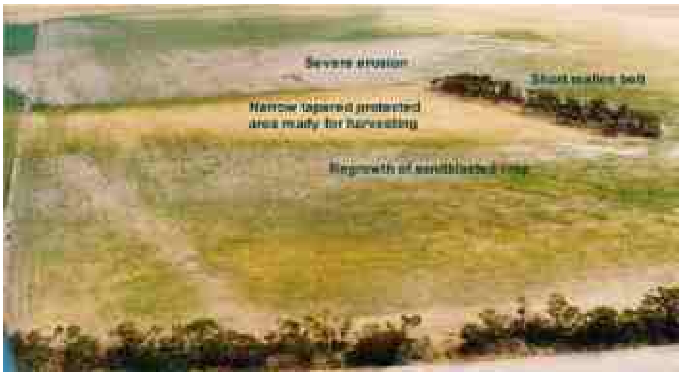


Photo Rob Murphy or Alex Knight

Often rubber-tyred tractors cannot rip sufficiently deeply

The area sheltered by short shelterbelts is inherently compromised. The length of belts should be at least 20 times the height.

From a financial viewpoint, minimizing the area of agriculture displaced is a 'must' (refer to *Analysis of options* on page 41) and includes:

- Planting on roadsides (subject to road safety design constraints) with local native species is a much much higher priority than internal shelterbelts that displace crops. Establishing internal shelterbelts before roadside belts is questionable - except where wind sensitive crops are grown (see *Shelter research results summary* below) and in special circumstances such as for a non-cropped raceway still wide enough to shift machinery after planting, for aesthetic considerations or a high priority corridor needed to link remnant native vegetation.
- Periodically deep ripping (every few years) to sever roots competing with crops and pastures can work where ripping is deep enough to reach a clay subsoil or hard pan; it is highly unlikely to be effective in deep sands.
- Keeping the width of the belt to a minimum without creating gaps which *can* be avoided even in single and double rows and even direct seeding - by replacing or filling in deaths and failures.
  See *Analysis of options* on page 41.

Erosion and damage during crop establishment due to wind tunneling through gaps in a 'shelterbelt' Photo - Rob Murphy

Shelter research results summary

The excellent Australian windbreaks research program recently completed by Helen Cleugh and many others measured crop responses to shelter - from improvement in growing conditions and reduction to damage at crop establishment and legume flowering. South Australian research indicates:

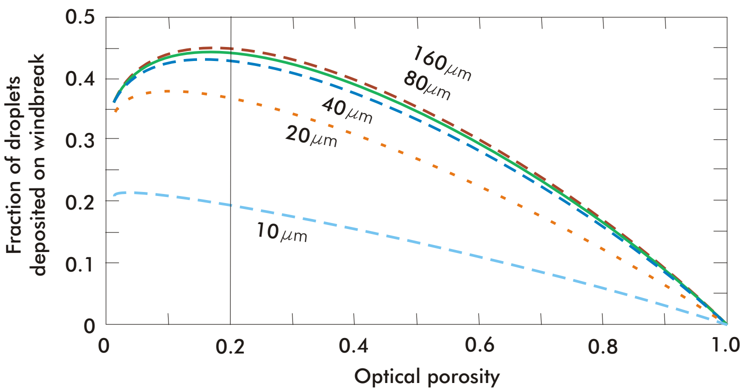
- Small yield gains of 5.2% and 3.7% for wheat and barley, respectively
- Considerable inter-seasonal variability, with relatively large net yield gains (7.5%) in 1997 and 1999, compared to virtually no net gain in 1998 and 2000 - suggesting responses are greater for cereals in drier, windier years
- An 18.7% faba bean yield increase to 19.6 windbreak heights
- A yield response range from 0-11.5% for lupin crops
- Yield losses of 18% for lupin plants that were sandblasted when young
- Only 5% and 9% reductions in yield for wheat and canola sandblasted soon after emergence
- Up to 30% flower abortion in faba beans from hot dry winds
- Severe head loss events in the prime barley-growing area of Yorke Peninsula in SA caused yield reductions averaging 15% in four years out of the seven for which data were available. For a paddock sheltered by a medium porosity windbreak, the incidence of moderate to severe head loss events (>5 heads/m^2/hr) in the period 1993-1999 was estimated to be reduced almost 10-fold at the most sheltered location (6H) and 35% across the whole paddock.

Spray drift buffer design principles
Reducing spray drift

The key findings of Mike Raupach's recent research indicate that:

- Spray droplets passing through a windbreak can be trapped by the foliage
- Larger-sized droplets are more likely to be deposited on the foliage than the fine droplets
- Highly porous windbreaks entrap very little of the spray drift, but wind bypassing 'brick-wall' like windbreaks takes spray droplets with it in the process

- Peak deposition of most particle sizes occurs with windbreaks with an optical porosity of 0.2 which is much denser than was commonly thought to be the case - so plant a dense belt and use species with fine foliage



Percentage of particles deposited to a porous windbreak depends on optical porosity and particle sizes. For most particle sizes, an optical porosity of 0.2 maximises the deposition to the windbreak (after Cleugh 2003)

Biodiversity principles

This section outlines the basic principles and briefly reflects on what revegetation projects can be realistically expected to contribute to biodiversity - protecting the diversity of flora and fauna and including the genetic diversity within species.

The biodiversity design principles involve:

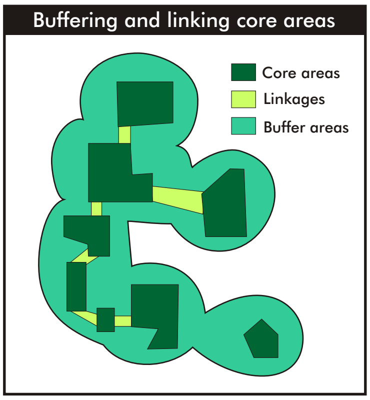
1. Keeping and **protecting remnant native vegetation** - may not be 'revegetation' as such but it is far more cost-effective for biodiversity than establishing new vegetation. This involves permanently excluding stock and controlling rabbits and weeds.
2. **Bigger areas** of native vegetation are better than smaller areas. Revegetating adjacent to existing native vegetation increases the total area of native vegetation and provides a buffer to weed invasion and exposure. For a rough guide, Hugh Possingham postulated that a minimum of 5 ha was required for effective insect and plant habitat, 10 ha for birds and reptiles and 40 ha for mammals.
3. **Block or round shaped areas** are better than narrow, long areas.
4. Linking areas of remnant native vegetation with revegetation helps overcome problems associated with fragmentation, particularly when complementary with neighboring and regional projects (see *Naturelinks* below).
5. Using as **wide a range of local species** as practicable (see page 70) to at least reconstruct a similar structure to remnant native vegetation should help to create more effective habitat. The structure may include a tree canopy, shrub layers and groundcovers/grasses.

Design principles

Creative revegetation - Enhancing biodiversity by design is a four-page fact sheet produced by PIRSA, the State Revegetation Committee and the Native Vegetation Council and includes well-illustrated principles.

The *Biodiversity Plan for the Murray Darling Basin* identifies 'More than 115 species of plants, mammals, birds, reptiles, frogs and invertebrates threatened at least regionally in the Murray-Darling Basin.'

The challenge for Regional Integrated Natural Resources Management Planners is to improve the conservation status of these species. Revegetation is only one option to effectively improve the precarious existence of these key species on a regional scale, but 'What are the most cost-effective revegetation options to pursue?'



Buffering and linking core areas (after NatureLinks *see box)*

Such options may include:

- Linking Brookfield Conservation Park to the riverine vegetation and revegetating areas adjacent to the floodplain that have high conservation value to provide connectivity
- Linking and buffering fragment remnant native vegetation within the key areas of Billiat and Ngarkat
- Linking and buffering fragments of blue mallee (*Eucalyptus cyanophylla*) in the northern Murray Mallee
- Protecting shrublands/grasslands/open mallee on the land units with shallow soils over relatively unbroken calcrete

Also see *NatureLinks.pdf* on the included CD-ROM.

The challenge is to:

- Use the precious little resources (time and funding) we have at our disposal to be as effective as possible - and leave a legacy of having made a real difference
- Really appreciate what the financial implications are for a farmers revegetation projects - leading to more informed decisions about the impact on farming sustainability

With respect to this last point, the key question is 'How do the benefits of the vegetation (such as shelter, insect predation, nitrogen fixation by leguminous species, improved soil structure and pollination) compare with the foregone agricultural income (as outlined in the *Analysis of options* section on page 41)?'

The principles of NatureLinks

NatureLinks is a bold biological conservation philosophy incorporating the following principles:

Plan at a landscape scale

Individual projects may be small in scale but need to be part of a 'bigger picture' maintaining populations large enough to enable ongoing evolution and involving an understanding of the relationship between habitat components in the landscape.

Restore habitat at large spatial scales

Habitat restoration, including revegetation, is a key component and needs to be undertaken on a large scale to be effective.

Managed species in fragmented landscapes to get an exchange of individuals between populations

Populations of species must be sufficiently large and contain enough genetic variability to resist local extinction due to inbreeding or chance events, such as floods or fire.

Adopt an 'ecological community' approach

Projects targeting ecological communities that are adapted to particular conditions of soil, topography, water availability and climate should provide good value for money.

Plan ecological restoration over long time scales

Short-term activities should be planned in the context of large-scale, longer-term ecological objectives that may take many decades to achieve.

Understand the ecology

An understanding of the ecological systems being managed or restored is important and provides the basis for adapting management when needed.

Wood and plant production principles

The two key products with real markets are broombush and firewood. Both may provide an opportunity for 'drought insurance' in the form of an income source in 'tough times'.

A serious search is on for species that can support new local 'integrated tree processing' industries based on products such as eucalyptus oil, activated carbon, energy and feedstock for composite and plastic products. But there is also still a huge challenge to improve establishment, management, and harvesting and processing systems to be competitive in the market place and as viable as the agriculture that it displaces.

Other products including sandalwood, cut flowers and ornamental foliage for floristry markets, wattle seeds and other bush tucker such as quandongs seem to be limited to cottage-industry scale.

So this section is restricted to outlining product specifications, species and spacing, location and layout, and harvesting options for broombush and firewood.

Product specifications

Firewood moisture content needs to be less than 20% and can be 'tested' by the sound made when two pieces of firewood are struck together. A nice bright sound indicates dry wood; a dull thud indicates wet wood. Bark persisting on any wood other than perhaps sugar gum (*E cladocalyx*) indicates unacceptable moisture content.

Single-row of flat-topped yate

As much bark as possible needs to be left behind during loading at the plantation. Conventional front-end loader buckets pick up too much bark and soil; a tyned or pronged 'bucket' that is hydraulically 'shaken' a couple of times before loading will help deliver wood with acceptably low bark levels. Otherwise wood can be dried to remove the bark and then crosscut.

Woodyards probably still require 'foot-wood' (250-300 mm). Even though most of the heaters now will take much longer pieces, pot belly stoves still require the shorter wood. The wood should be split if greater than 150 mm in width.

Regularity of supply, supply towards the end of the season and consistency in quality are valued by the woodyards but supplying small volumes is generally acceptable.

Cut stems' of any of the mallee species make excellent firewood. There's just one proviso for using local native species in relation to harvest time. The mallees will probably be in rows, but it is prudent to keep planting records to satisfy the Native Vegetation Council if needed.

Sugar gum and flat-topped yate (*E occidentalis*) produce good firewood and can be faster growing on the heavier soils in the less arid southern zone of the Murray Mallee. Flat-topped yate is salt tolerant and excellent for seepage areas adjacent to irrigation.

'Berries' and coarse-angle forking (rejected)

For hand-packed fences, the brush cut from **broombush** (*Melaleuca uncinata* not silver broom, *Baeckia behrii* that looks similar but is not durable) needs to have:

- many fine erect and straight branches that are relatively uniform in length
- very acute-angled forking
- few woody fruiting capsules (known as 'berries').

The Bowmans from near Lameroo have however recently developed machinery for packing high-quality panels, even using lower quality brush.

Plantation near Lameroo

Spacing

Trees grown for **firewood** need enough space to avoid ending up with too many suppressed small-diameter trees. Such trees are just not worth harvesting - it takes 'all day' to get a tonne of wood from 'wrist-sized' material. The suppressed trees also inhibit growth on the better trees. Somewhere in the range of 4-7m between trees (200-600 trees/ha) will be about the mark - higher density in the southern areas and better soils and vice versa.

In contrast with firewood, quality and yield improve with increasing planting density for **broombush** - up to 10,000 plants/ha or 1m between bushes. On the other hand, open-grown bushes seem to grow in a basket-shape with coarse, rather than fine stems, hence are unusable, however the coppice regrowth quality may be superior.

The trade-off between seedling cost and density seems to be approximately 4500 plants/ha or 1.5m between bushes. Direct seeding can achieve spectacularly high plant densities but there are inevitably big patches of 'no survivors', requiring filling-in with seedlings the following year. Seedlings can be very easy and cheap to produce as there is no need to 'prick out' or thin seedlings. Talk to Clive Bowman at Lameroo or State Flora at Murray Bridge.

Chainsaw felling and crosscutting

Cross-cutting, splitting and loading

Mill and tip truck

Location and layout

Getting areas large enough to mechanically harvest, providing access tracks and avoiding excessive slopes are of little relevance to the Murray Mallee. Planting can be done on any scale, any configuration (mainly blocks or belts) and any location for firewood; broombush could even be included in a shelterbelt but is most likely better in blocks.

The key consideration is the value of agriculture displaced by the trees. Trees almost invariably grow better on the better cropping soils, but the returns are highly unlikely to exceed the value of agriculture displaced (see *Analysis of options* on page 41). Un-ripped edge trees and linear designs compete with crops and pastures hence are more productive than block designs. The extra production is at the expense of displaced agriculture.

Harvesting options

Normal farm equipment is all that is needed - chainsaw, front-end loader ideally with a modified bucket to let bark and rubbish fall out, a tip truck and maybe an hydraulic block splitter.

Firewood mills produced in Scandanavia are available in Australia for a modest capital outlay. These mills process (cross-cut and split) and also load the wood in one operation but are probably better suited to medium-scale operations in plantation-grown timber in higher rainfall areas. Mallee stems are unlikely to be straight enough to easily process.

It may be prudent to check local government regulations regarding change of land use for farm forestry.

Fodder production principles

Fodder reserves such as saltbush fodder blocks are of greatest value during the autumn-feed-gap and periodic droughts.

This section outlines some fodder production options from woody perennials and some grazing management requirements that influence the design principles that affect project viability - involving species, layout, location, spacing and 'grazing cell' size.

Species

Oldman saltbush (*Atriplex nummularia*) is the main fodder species option for non-saline land being utilised in Murray Mallee farming systems. Other saltbush species such river saltbush (*A amnicola*) which is possibly more productive and palatable than oldman saltbush, grey saltbush (*A cineria*), quailbrush (*A lentiformus*) and wavy-leaved saltbush (*A undulata*) can be productive on saline land.

The reputation for high tannin content and low digestibility of *Acacia saligna* foliage seriously questions the merit of planting it. *Acacia saligna* did provide subsistence fodder in the 2002 drought, but some 'pioneer' alley farmers are in fact clearing it.

Tagasaste (*Cytisus proliferus*) production systems can be well matched to deep sandy sites in the Upper South East but growing tagasaste is falling out of favour for two reasons. The quality of the feed declines in autumn, just when it is most needed and 'clay spreading' is becoming a more common practice as it markedly improves crop and pasture production on deep sands of the Upper South East. *Medicago arborea* (tree medic) may be worthy of evaluation for drier areas.

Mixing fodder species invariably results in the more palatable specie(s) being eaten out and damaged before less palatable specie(s) are adequately grazed.

Layout and location

Saltbush alley farming east of Swan Reach

Saltbush can be grown in blocks or alley farming systems.

Alley farming systems based on belts of saltbush and alleys of crops/pastures on land subject to wind erosion (Class IV in particular) potentially offer increased production and valuable soil and stock protection along with effective elimination of groundwater recharge in the area occupied by saltbush roots. Class VII land planted in belts with alleys would still be likely to be at risk.

It is widely believed that stock do better on a mixture of traditional pasture and saltbush than they do on saltbush alone in which case they only maintain body weight. So, cropping and grazing of the alleys also should reduce or even avoid the need to cut and carry supplementary hay for stock when feeding on saltbush. *Oldman saltbush* outlines how to work out alley widths as multiples of crop machinery widths.

Healthy vigorous 2m-tall saltbush on >3m-deep sands near Swan Reach

Blocks of saltbush provide marvellous stock shelter for lambing and off-shears sheep - even better than that provided by alley systems. It has been commonly planted in rows 3m apart and 1.3-1.8m apart within the rows with plant density of 1800-2500 plants per hectare.

As a principle, increasing the gap between plants within the rows and especially distances between rows reduces establishment costs, provides plants with more growing space and will reduce the extent of, or even eliminate supplementary feeding required. Ray O'Malley plants at approximately 1670 stems per hectare in double rows 2m apart with a 6m gap between the double rows. Spacing between plants within the row is 1.5m.

Spacing rows wider than 6m apart on wind erodable soils risks erosion in the root competition zone and should be avoided.

Note that supplementary feeding can also be reduced or eliminated by providing stock free access to adjacent pasture or stubble - but the stocking rate still needs to be high enough to effectively crash-graze the saltbush. The importance of reducing the level of supplementary feeding is highlighted in the *Analysis of options* section.

Planting blocks (or belts) on deep sands can be very productive when nutrition is adequate and on shallow soils not suitable for cropping provided that the limestone is not severely calcreted, allowing roots to explore the subsoil (marl). Very productive growth can be found on sites with P levels of approximately 30ppm, provided N levels are also adequate. Impressive growth is noted on sites with history of legume crops and/or applications of pig manure and bushes adjacent to the carcasses of dead sheep - indicating that N must play a key role in maintaining good health and productivity.

Avoid planting:

- Belts (or blocks) of saltbush on highly productive cropland as they are most unlikely to be productive enough to offset the value of the crops displaced
- Blocks (or belts) on severely calcreted grazing land - even if the saltbush has a higher carrying capacity than the prior pastures because only the few bushes with roots that find a crack in the calcrete or solution hole will be able to exploit sub-soil moisture reserves under the calcrete

- As indicated in the *Establishment* section, mounding on shallow stony soils increases the soil volume and the capacity of plants to survive and find any cracks in the calcrete.
- It may be possible to assess the extent of calcreting by removing a strip of topsoil say 10m or longer by 1m or so wide in a number of areas of the paddock being considered for saltbush. In the absence of a front-end loader, try using a fire fighting rake-hoe to scrape the soil away to expose the limestone 0.5m by 10m, then use a stiff broom to 'show' any cracks in the calcrete.

Inadequate moisture and nutrition both lead to a greater susceptibility to insect attack and result in poor productivity and bush persistence. Applying N; N +P; and N, P, Zn and Cu to both moribund (sick) and relatively healthy saltbushes only resulted in modest increases in leaf area when casually observed six months after application (top left photo) - probably not enough at that early stage to be an 'economic' response.

On the other hand, on a very infertile site Ray O'Malley impressively invigorated many of the bushes that appeared dead, simply by applying 40kg/ha of DAP. The before and after sequence photos on the right illustrate the regrowth hiding within what was an apparently dead saltbush in a very infertile weak patch.

The viability of both blocks and alley farming systems needs to be determined by comparing the value of the fodder production initially, and perhaps protection too, with the cost of establishment plus the value of agricultural production displaced. The economics of these scenarios are highlighted on page 44 in *Analysis of options*.

Grazing management

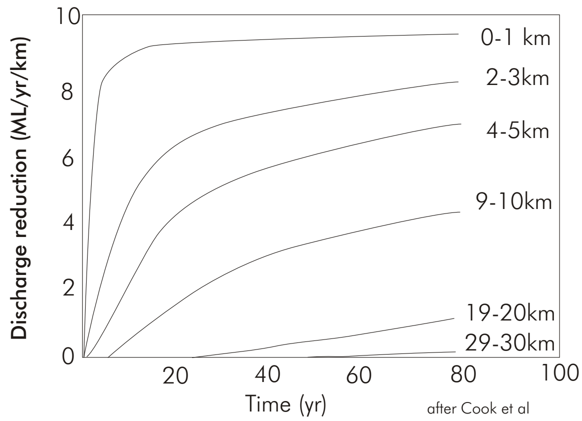
Saltbush needs to be crash grazed with adequate stock numbers to have removed most of the leaf, generally in less than six weeks, then spelled for 68 months. Not allowing the bushes to re-shoot and recover by leaving the stock in too long will kill bushes and set stocking can be expected to kill the most palatable and weakest bushes first.

To crash graze the saltbush in six weeks, one farmer works on the basis of 100 sheep per 4ha (10ac) - 300 sheep per 12ha (30ac) with one large round bale of hay per week. The size of the grazing cell will depend on the flock size, but the publication *Oldman saltbush* describes a 6ha-block system.

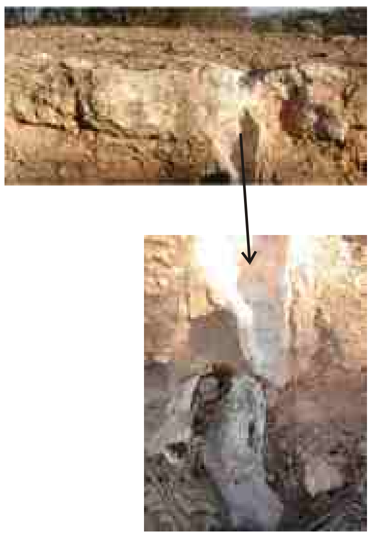
High water use principles

Even though water tables in the Murray Mallee continue to rise as a result of land clearance, the water table is still more than 20m deep in most of the region. The water table is only closer to surface near the coast and in a small zone running south east from Loxton-Renmark to across the border. The water table may be deep enough not to salinise most of the region's farmland but the rising water tables are increasing the flow of saline groundwater entering the Murray.

Reducing the leakage under farming systems in a corridor close to the Murray is understood to have a far greater impact on reducing saline groundwater inflows in terms of both the volume of flows and the time frame. It will 'only' take decades for revegetation to have an impact 5-10km from the Murray, but centuries for most of the rest of the Murray Mallee.



It seems to follow that for most of the region, reducing recharge in the corridor should be a priority for public investment. On the other hand, reducing recharge in non-corridor areas can only realistically be expected to result from the development of more profitable farming systems that involve the use of perennial plants in some way. Neither can the threat of farmland becoming saline, as is the case in the WA wheatbelt or the Coorong Districts, nor the expectation of public investment be expected to drive the change - only the prospects of increasing farming system profitability might, leaving any reduction in groundwater recharge as a bonus.



Solution hole used or caused by mallee 'sinker' root

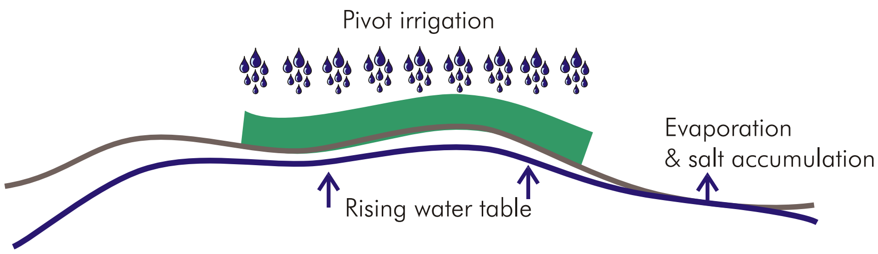
No doubt there would be some minor leakage under farmland in most years, but most of the recharge is thought to be episodic - associated with uncommon heavy rainfall events that can occur in summer when annual agricultural plants have finished their life cycle. Deep sandy soils and shallow calcreted soils are likely to be more prone to leakage.

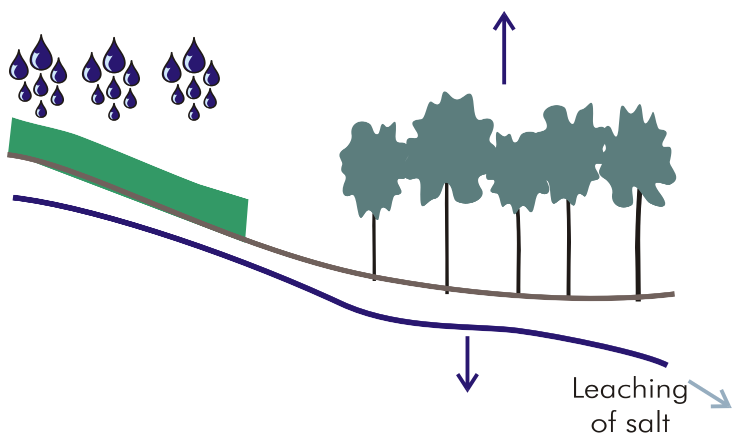
Planting perennial vegetation permanently or periodically as a phase crop on most soils including deep sandy soils should effectively eliminate recharge. This is much less likely to be the case for shallow calcreted soils that cannot support the same leaf area as sites with deeper profiles. The shallow sites generally only support a bullock bush shrubland and it is easy to envisage water being channeled down solution holes (photos) to the watertable faster than the shrubland's limited root systems could extract it.

So, for that critical corridor (and areas further away from the river), periodically or permanently establishing most perennial plants (perennial pastures, revegetation with local native species, broombush or firewood blocks) should effectively eliminate recharge on all soil types except for the shallow severely calcreted soils. The 'lucerne return interval' may need to be slightly less than 10 years for the dunes but more than a century for the swales. It could be worth using a soil auger to monitor the progress of the wetting front in the deeper sands after a big rainfall events; it certainly is when establishing perennial vegetation.

In some parts of the Murray Mallee there is a more pressing local need for increasing water use:

1. Seepage at the base of sandhills induced by pivot irrigation also provides excellent opportunities for revegetation by establishing bands of salt-tolerant species such as flat-topped yate (*E occidentalis*) to intercept water before it reaches the surface. Perennial vegetation can be established on un-irrigated paddock corners and lucerne can be used to dry out the soil profile following an irrigated crop.
2. This approach can also apply to interception of shallow water tables in the proximity of the Noora Evaporation Basin.





Native pine (Callitris spp)

Eucalyptus cyanophylla

Eucalyptus porosa foliage

Aesthetic principles

The aesthetic value of revegetation may be very subjective, but can still affect property values and working conditions, so this section considers a few different concepts.

Vegetation naturally grows in associations that have an identifiable character because of the shapes, colors and textures of the dominant species. For example, native pine has deep green foliage and dark trunks, blue mallee has waxy blue-gray foliage, mallee box and sugarwood have bright green foliage in comparison with the drab olive green of many other mallee species.

The approach of planting one or two of everything might produce a fine arboretum with something of interest most of the time. It can however lack the distinct **character of plantings that emulate natural vegetation associations that only have 2-3 dominant tree and shrub species**. These associations of trees and a variety of shrubs also often flower throughout most of the year. For example, dryland tea tree flowers prominently in the height of summer.

The regimentation of straight lines appeals to many and with the grid of roads and paddocks there is often little opportunity for much flexibility. Indeed, the avenues of pines, sugar gums or pepper trees along property entrances are common and can express an orderliness and custodianship of the land.

On the other hand, **following natural features such as defined by land capability boundaries** can be more universally appealing and harmonious.

Potentially at odds with shelter design principles, any revegetation completely blocking views into paddocks when driving past may not only hinder the checking of stock and crops but also hamper variety in the vistas of the property and surrounding landscape. On the other hand, **well-located patches of vegetation can create new vistas** and interest in going from A to B on the property - in a strong contrast to being able to scan most or all of the property from any point.

It could be well worth 'playing around' with a few different options on a plastic overlay of the farm's aerial photo.

Further reading

Abel N, Baxter J, Campbell A, Cleugh H, Fargher J, Lambeck R, Prinsley R, Prosser M, Reid R, Revell G, Schmidt C, Stirzaker R and Thorburn P 1997 *Design principles for farm forestry* Rural Industries Research and Development Corporation, ISSN 1321-2656 - considers interactions between designing for timber, salinity & waterlogging, rehabilitation of degraded land, shade and shelter, biodiversity and landscape/aesthetics, but is more applicable to areas with more rainfall than the Murray Mallee (102p glossy booklet); visit www.rirdc.gov.au for details

Bartel B and Knight A 2000 *Oldman saltbush Farmer experience in low rainfall farming systems* Primary Industries and Resources SA, ISBN 0 7308 4399 8 - very usefully reflects on variances between the discouraging results of grazing studies on the value of saltbush and more positive farmer experiences, principles for design, establishment and management and a couple of financial analyses (24p glossy A4)

Bulman PA 1994 *Farmtree$ for the Mt Lofty Ranges a regional agroforestry handbook* Primary Industries and Resources, SA, ISBN 0 7308 0646 4 - Chapter 7 also applies to the Murray Mallee outlining wood quality, planting density, growth rates, harvesting, marketing, profitability and coppice management; available from PIRSA and State Flora

Bulman PA, Beale P and Knight A 1998 *Growing broombush for profit and land protection* Primary Industries and Resources, SA, Bulletin 1/98 ISBN 0 7308 4314 9 - outlines most aspects of establishing, managing and harvesting broombush as well as identifying the key factors affecting profitability (24p colour A4); available from PIRSA and State Flora

Bulman PA 2003 *Shelter systems what are they worth?* Special Liftout, Australian Forest Grower, Vol. 26, No. 4
- synthesizes the overseas and comprehensive recent Australian research on crop shelter responses, outlines how to design for purpose and the challenge of coming up with a cost-effective design for a Wimmera case study (8p); see *Shelter systems.pdf* on included CD-ROM.

Bulman PA and Dalton GS 2000 *Farm revegetation design Optimising your benefits* Primary Industries and Resources, SA, ISBN 0 7590 1302 0 - uses a case study in the eastern Mt Lofty Ranges to clearly illustrates design principles and the associated economic trade-offs on a whole-of-farm scale (49p glossy A4); available from PIRSA

Cleugh HA 2003 *Trees for shelter; a guide to using windbreaks on Australian farms* Agroforestry Guideline Series 2, RIRDC publication 02/059, ISBN 0642 58458 3 - well illustrated glossy booklet synthesising the results of recent excellent Australian shelter research; visit www.rirdc.gov.au for details

Cook P, Leaney FW & Jolly ID 2001 *Groundwater recharge in the Mallee Region and salinity implications for the Murray River a review* CSIRO Land and Water Technical Report 45/01 - provides an appreciation of where most of the saline groundwater is entering the Murray and illustrates how revegetation is most effective when located within 'cooey' of the river; copy of 132 page report in MMLAP office

Department of Environment and Heritage 2003 *NatureLinks Implementing the WildCountry philosophy in South Australia* Department of Environment and Heritage, Adelaide - shows linkage of key remnants in the Murray Mallee in context to a grander State plan and outlines principles of protecting, buffering and connecting remnant native vegetation; see *NatureLinks.pdf* on the included CD-ROM

Murray Mallee and Murray Plains Soil Conservation Boards (2003) *Stopping the sand drift* Fact Sheet

Foulkes JN and Gillen JS (Eds.) 2000 *A biological survey of the Murray Mallee, South Australia* Department of Environment, Heritage and Aboriginal Affairs, South Australia ISBN 0 7308 5872 0 - identifies 57 floristic vegetation groups based on dominant species from baseline biological data from an extensive survey with 35 mapped groups occurring in South Australia; lists associated species; shows locations and describes land form, (top) soil texture, calcrete characteristics and rainfall, but does not lend itself to easily constructing revegetation species lists for different site types; lists 15 threatened plant species; includes a map of the remnant vegetation, but is not that easy to interpret using the key; mainly for the devotees and is available from the Department of Environment and Heritage, Keswick for $38.50

Kahrimanis MJ and Carruthers S 2001 *Biodiversity plan for the South Australian Murray-Darling Basin* Department of Environment, Heritage and Aboriginal Affairs, South Australia - identifies major threats, actions to reduce threats, threatened species and recovery plans, 13 key biodiversity areas (large remnants, fragmented areas and threatened habitat areas; available from DEH in Berri or Keswick

Knight AJP, Blott K, Portelli M and Hignett C 2000 *Use of tree and shrub belts to control recharge in three dryland cropping environments* Aust. J. Agric. Res., *51*, 000-000 0004-9409 - provides insights into root development and the impact on stored soil moisture and adjacent crops; try the Waite library

Knight AJP, McGrath and Lawes 2000? *Low rainfall alley farming systems A guide to alley farming in the 300-400mm rainfall zone of the Murray Darling Basin* Primary Industries and Resources SA, Adelaide, SA

Leys J & Murphy S 2002 *Risk of deep drainage on the Mallee Sustainable Farming Project paddocks* NSW Department of Land and Water Conservation - provides an appreciation of leakage under different rotations for a range of soil types, an indication of how often lucerne is needed to dry out soil profiles and how much stored soil moisture is needed to get satisfactory production. There is copy of the related report in the MMLAP office for the project *Land management options for the control of recharge in the mallee region of SW NSW* by Margaret McKellar in 1996 from the NSW Department of Land and Water Conservation. See *Risk of deep drainage.pdf* on the included CD-ROM.

MMLAP (undated) *Revegetation Fact Sheet Series: Wood and products; Fodder; Shelterbelts; Enhancing remnants; Protect remnants and Local native species* Mallee Futures Program - useful introductory fact sheet series available in hard copy and from http://lm.net.au/~murraymalleelap/

Mt Lofty Ranges Private Forestry 2002 *Adelaide woodyard survey* Appendix to a report done by Forest and Natural Resources for Mt Lofty Ranges Private Forestry - includes product specifications; small, medium and large-scale harvesting systems; and marketing strategies. Visit www.mlrpf.asn.au

Mt Lofty Ranges Private Forestry 2002 *Harvesting systems and marketing strategies for firewood plantations in the Mt Lofty Ranges* Brochure (8p) prepared by Forest and Natural Resources for Mt Lofty Ranges Private Forestry - includes species, product specifications, sources of supply, reliability of supply and retail and wholesale pricing; visit www.mlrpf.asn.au

MMLAP 2003 *An evaluation of revegetation options used to reduce recharge* A report prepared by Farm Tree Systems for the Murray Mallee Local Action Planning Association - provides a more detailed synthesis of the region's soils and hydro-geology and the results of investigations into the factors affecting the success or failure of revegetating with lucerne, saltbush and local native species; see *Evaluation of revegetation options.pdf* on the included CD-ROM

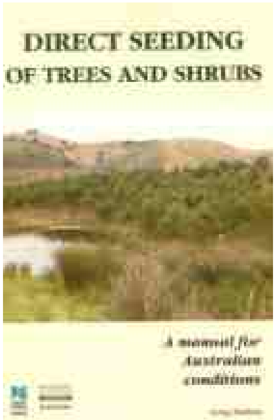
Raupach MR and Leys J 1999 *The efficacy of vegetation in limiting spray drift and dust movement* CSIRO Land and Water Technical Report 47/99

Stirzaker R. and Lefroy EC 1997 *Alley Farming in Australia: Current research and future directions* Joint Venture Agroforestry Program, Rural Industries Research and Development Corporation Research Paper No 97/29 - useful background and earlier thinking; download from www.rirdc.gov.au or see *Alley farming in Australia.doc* on the included CD-ROM

Sudmeyer R 2002 *Tree root morphology in alley systems* Joint Venture Agroforestry Program, RIRDC Publication No 02/024 - provides an understanding of the importance of root competition control and the inherent constraints of ripping on deep sands; download from www.rirdc.gov.au or see *Tree morphology in alley systems.pdf* on the included CD-ROM

This section is more informative than prescriptive, hopefully leading to well considered choices and better results. The section *Revegetation using native species* is drawn from a reasonably thorough assessment of revegetation projects in the Murray Mallee in conjunction with the wider knowledge and experiences. The full report from this project, *Evaluating revegetation options used to reduce recharge* can be found on the CD-ROM.

The coverage for *Saltbush* and *Perennial pastures* is restricted to a summary of key points from authoritative sources of information.



Revegetation using native species

Much of the discussion below focuses on the challenges of direct seeding. Planting seedlings may be a little more costly but can be more reliable than direct seeding in low rainfall areas. The two techniques share the same principles of weed control and timing and can be complementary - by planting seedlings and even cuttings of less-easily direct seeded species to increase the species diversity of revegetation projects.

Greg Dalton's *Direct seeding of trees and shrubs* is a very useful well-illustrated Australia-wide guide on direct seeding, complementing the outline below which has a Murray Mallee focus and includes: moisture conservation; seed placement; seedling development as related to time of seeding, soil texture and rainfall events; and insect predation.

Conserving moisture

Weed control is absolutely fundamental for effective moisture conservation and successful establishment of seedlings and direct seeding - and may even need to start the year before seeding if there are hard-to-kill perennial weeds present such as skeleton weed, kikuyu and couch. Also, in many circumstances a summer fallow will help build up soil moisture storage - just as is the case for crops.

Pre-planting and pre-seeding cultivation(s) by ploughing or even rotary hoeing can provide initial weed control, a good surface for herbicide application, aid water penetration and help conserve moisture in cracking clays. It does however increase the risk of wind erosion and without follow up, it is generally highly ineffective for longer-term moisture conservation. The next germination of weed seeds thrives on the 'fallow' very much at the expense of the native plants. Ideally, **no weeds should be within a half a metre from the seedling for the first winter, spring and summer.**

Post-planting and post-seeding cultivation can control successive germinations but is difficult to do without damaging the young seedlings. Spraying with a knockdown herbicide such as glyphosate down the planting line with equipment that will shield the plants from spray drift is easier than cultivation and also does not have the risk of damage to young plants commonly associated with residual herbicides such as simazine.

Such ploughing and/or spraying can however often be avoided by **scalping or grading away the topsoil - removing weeds, many weed seeds and water-repellent sands** to provide a relatively weed free environment over the first winter, spring and summer. V-blade machines (as illustrated) effectively scalp 80cm-wide weed-free strips that are more effective than discing a 25 cm wide trench. Having the weeds a little closer to the plants at the edge of the scalp is okay because of the extra moisture available 'down the scalp line'.

The scalping and seeding is carried out in a one-pass operation, but a heavy stubble or cover crop is needed between the planting lines to reduce erosion and burial of seeds in sandy soils.

Actively eroding dunes need to be stabilised prior to revegetating - commonly involving earthworks and establishment of a cover crop as outlined in the Appendices on page 65.

Seeding rate

Direct seeding of trees and shrubs details the number of viable seeds per gram, expected range of percentage establishment and suggests seeding rates in grams/km for six genera to achieve a natural bush effect.

An example of machinery capable of appropriate seed placement and seed-soil contact. Note that the tyne is not penetrating the soil and needs adjusting.

Placing seed

Machinery able to:

- Place large-seeds approximately 510 mm deep
- Place small-seeds on the surface
- Lightly cultivate the soil
- Compress the soil to gain intimate seed-soil contact

will give seeds better prospects for germination than machinery that cannot.

Successful germination of seed placed on the surface by machinery can only be expected when there are low levels of ant predation (see below) and unusually protracted wet periods enabling the surface soil to stay moist enough for long enough to allow satisfactory root radicle development.

Timing

Rapid root development prior to summer is critical for survival and growth and is affected by the time of planting or seeding. The effect of timing on root and shoot development is illustrated on the right.

Although it is clear that an early start is clearly desirable, there are some trade-offs for direct seeding:

- The colder winter temperatures and associated slower growth rates make young germinants highly susceptible to sap suckers (see the discussion on *Insect predation* below)
- If chemical weed control rather than scalping is used, there is a longer period (winter, spring and summer) to keep the site weed free and greater opportunities for successive germinations of weed seeds

Seeding later than June is generally considered too risky. The prospects of a seed germinating in July or later and then successfully 'chasing the moisture' down the soil profile are low. This is especially the case on soils without a fully wet profile, ***unless good spring rains are enjoyed*** - like those experienced in September and October 2001.

Spring sowing can occasionally work however when there is good soil moisture storage, good spring rains and a summer thunderstorm or two - a considerable gamble in the absence of a crystal ball.

For example, a successful August sowing near Paringa (see photo on the right) in the drought year of 2002 highlights what can be achieved when there is subsoil moisture being held within 20-30 cm of the surface (see the photo with the soil auger on the next page). The winter rainfall may have been well below average, but conserving this small amount of moisture that was available (more than 50 mm) by preparing the site the same as for a no-tillage crop worked. Warm moist soil promoted rapid germination and root radicle development. Rainfall in December (12 mm) and February (21.6 mm) unquestionably influenced survival and growth.

A browsed 8 month old Acacia ligulata sown in August 2002 with a 2 month old germinant following rains in February 2003 - photo taken in April 2003

Sowing in dry soil before the break of the season can also be successful but only if adequate weed control is achieved (for example, by scalping). But aiming to direct seed two to three weeks after the opening rains (generally late autumn and early winter) must be a lot 'safer'.

The dramatic effect that soil texture has on how quickly soil profiles dry out and how this relates to the timing are discussed in *Seed germination and development* on the next page.

Seed treatment

There are three common seed treatments used in nurseries and prior to direct seeding:

- Hard seed coated species such as *Acacias* and other leguminous species need to be **heat treated** (covered in water just off-the-boil, then soaked) or **scarified** (abrasion to remove part of the seed coat but at the risk of damaging some embryos)
- Other species such as native pine benefit from **cold stratification** (being kept cold in the fridge to simulate a cold wet season).

Treating with **smoke** breaks dormancy and aids germination of seed of some hard-to-germinate species further information is available from the nursery industry and the *Society for Growing Australian Plants* which has related information on their website

Direct seeding of trees and shrubs outlines two germination tests and details seed treatments for an impressive range of genera and species. *What seed is that?* provides a field guide to the identification, collection and germination of native seed in South Australia.

The species list in *Appendices* notes which species are easy and hard to propagate.

Seed germination and development - soil texture interactions

There is poor establishment in the row adjacent to the fence which has more drift sand relative to the adjacent rows to the left

Soil texture has a major impact on successful seed germination of seed and early development of seed and seedlings.

Sands with little loam, clay and organic matter rapidly dry out in the germinating zone.

Soil moisture also quickly drains from the upper part of the profile providing a major challenge for seed germination and rapid root development.

An indication of the problem with such coarse sands is often illustrated with the poor rates of success:

- On row adjacent to fences where drift sand has accumulated (photo on the right)
- On dunes in comparison with flats

Moisture from recent light rainfall in the top 510 cm, with a narrow band of dry loamy sand overlying abundant moisture from the February 2003 rains at 2030cm being held in a heavier-textured clayey sand typical of the lower slopes and flats

The photo on the right illustrates a soil profile of loamy sand over clay dug in April 2003 showing the moisture from February rains conserved at 20-30cm depth - explaining the success often experienced on the flats relative to sand hills that had moisture from the February rains at 50-60cm depth.

It may be easy for roots to explore sand, but **drying of a sandy profile** to 50-60 cm over a two-month period equates to the 'wet zone' dropping at about 1 cm per day. If two weeks is the period required for seed to germinate at that time of the year, the germination zone would need to be continually moist for that period. If this were followed by a two-week dry period, the 'race' would be on between root development and speed of moisture drainage or dry 'front'. If the soil profile is re-wet in late July, and periodically dries and is re-wet for the last time in late September, by late December, the root system may have to be up to 90 cm deep in deep dune sands. That is quite a challenge but achievable by species such as native pine. Longer dry spells in July and August would risk desiccation. An earlier finish to the season may require more rapid root development and seedlings with less developed root systems are not likely to survive.

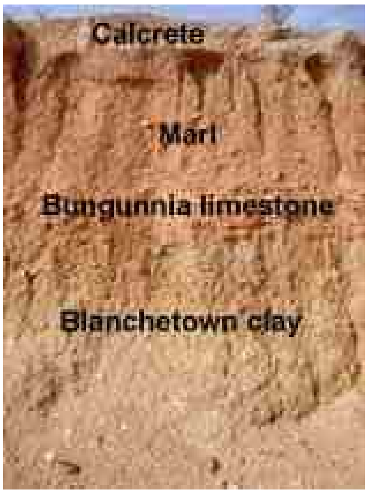
Rapid root development is not likely to be supported by the low inherent fertility of dune sands but could be easily redressed by applying **fertiliser** at seeding, but in a slow-release form that doesn't burn the young germinant's roots.

Deeply planted **seedlings** are more likely to stay within moist sand. Seedlings that are literally soaked before planting will minimise transplant shock. Recently fertilised seedlings will be capable of far quicker 'get away' than seedlings that have been starved of nutrients, but more susceptible to frost damage if too 'soft'. If the soil is 'dry' and if there is no significant rain imminent, 'puddling-in' the seedlings by pouring a litre or two of water into the planting hole can be expected to dramatically improve survival.

On the other hand, **watering over summer is rarely effective**, hence rarely warranted. Plants that need watering to survive over summer will need to have been watered by early December; seedlings alive at Christmas already have well developed root systems and a very good chance of survival without watering. To be of any use, *at least* 20 litres of water is needed requiring a major effort and associated cost to construct an adequate basin for large-scale projects. Effective weed control is likely to be much more cost-effective.

Applying a **water-based bituminous emulsion** can significantly aid germination on coarse textured soils. The black emulsion increases surface soil temperature, reduces moisture loss from the germination zone and stabilises the soil in the seed trench. However, the additional expense of materials and application equipment, material handling, lower productivity and reluctance of operators to use it due to the messiness and inconvenience of blockages, may outweigh the advantages. Costs could be kept down by niche seeding - automatically placing and mulching the seed, say every metre or so. Also, observed higher mortality over summer negate to some degree the superior germination and early plant development. It would be interesting to understand if the mortality was caused by competition for moisture or excessive summer temperatures.

Successful germination and extraction of moisture from seedlings of native species is most improbable from saline and sodic clays as illustrated. Note the scalded soil in the foreground and where the person is standing.



Blanchetown clay (as labelled) underlying Bungunnia limestone in a soil profile between Morgan and Swan Reach

A difficult-to-establish shallow stony site characterised by the named species

Surface-soil **water repellence** will prevent germination and may not be a major problem in the northern mallee, but is certainly an issue on dune sands and sands that have not been regularly cropped. Test the soil by timing how long a drop of water takes to soak into dry soil; if it is longer than 10 seconds there will be problems and scalping or applying a soil wetter (surfactant) will be required.

As indicated and illustrated above, well-structured **loams** provide the best prospects for revegetation success. Moisture holding capacity in terms of plant available water is superior to sands and clays. This provides germinating seed and seedlings the least challenge to access adequate moisture for summer survival.

Clays hold more water but they take more moisture to wet the profile, a lower proportion is extractable by plants and they can become rock hard over summer. Drainage from clay soils is slower but root penetration in uncultivated soils will be slower than for lighter textured soils.

Sodic clays are likely to be poorly structured and affect root penetration, but they are also likely to be saline and make extraction of moisture very difficult.

The extent and influence of sodic and saline soils derived from Blanchetown clay seems to be more widespread than generally appreciated and is important to identify and avoid.

Note that some of the sodic clays can appear to be quite friable, hence appear to be suitable for direct seeding and planting.

Sodic clays are often also saline and can be identified by using a conductivity meter in a 1:5 mixture of soil to deionised water and/or by placing a ped (crumb of soil) in water and seeing if it collapses or holds its shape. If it collapses or disperses it is saline.

Ripping can enhance moisture penetration and root development, hence survival on heavy-textured soils and soils with a hardpan, but insufficient compaction following ripping will reduce seedling numbers. If you can't push a pencil into the clay when moist, deep ripping is warranted.

Shallow and stony soils are prone to drying out rapidly. The prospects of experiencing a period of regular rainfall events long enough to maintain a moist germinating environment can only be expected to occur in exceptional seasons.

Valuable indicator species for such sites are *Lawrencia spp* and *Acacia nyssophylla* highlighting the low probability of success of direct seeding.

Tackling such sites ***is*** likely to require a commitment to summer irrigation.

A root mat indicating shallow topsoil soils with a very stony profile formed from the Bakara limestone deposits

Natural regeneration on unoccupied shallow stony soils (and deeper dunes) is more than likely to only have occurred in seasons that have an early start and a late finish and/or have really significant summer rainfall events followed by an early break to the season.

Insect predation

In the southern and central Murray Mallee sap suckers including red-legged earth mites and aphids will 'suck young germinants white' during the colder months. *Direct seeding of trees and shrubs* advocates monitoring, and if required, spraying of a systemic insecticide such as Le Mat® or Rogor® at 'label rates' approximately four weeks after opening rains before RLEM lay eggs and then 4-6 weeks later if required. The first spray can be mixed with a herbicide for weed control.

Seed burial as described above is important to reduce ant predation even then the small seeds will be more vulnerable than the larger seeds.

Planting equipment suitable for saltbush and other seedlings

Oldman saltbush **includes guidelines on plant protection, fertilising, follow-up weed control and grazing management.**

Saltbush

The key steps to success for **planting** saltbush can be found in *Oldman saltbush* and are summarised as follows:

1. Control weeds making sure that summer active perennials are controlled prior to establishment
2. Rip hard-setting soils but avoid air pockets by ripping in time to allow natural consolidation, ripping soil that is not too wet or dry and/or driving a tractor over the rip line after ripping
3. On wind erodable soils, use a cover crop suitable for the soil type
4. Plant:
    - Into shallow scalped planting lines on non-stony well-drained soils as soon as possible after the break of the season
    - On mounds in shallow stony soils to increase the soil volume, hence opportunities for roots to explore and find cracks in the calcrete
    - On mounds in spring on poorly drained and saline sites with mounds constructed a year in advance
5. Plant disease-free seedlings or cuttings using a machine or planting tube along with 10-15g of slow release fertiliser (using high analysis fertiliser risks burning plant roots)
6. Saltbush is tough, but unless the soils are very moist, water-in with a small volume of water

Direct seeding can be cheaper and successful - the key steps are summarised as follows:

1. Collect seed during the summer months
2. Check that the bracts contain seed
3. Strip and shake fruiting branches into a container
4. Clean further to remove twigs and leaves
5. Soak 4-5kg of seed bracts in a hessian bag overnight in a 44 gallon drum
6. Fill the drum completely with water and rinse four times the following day
7. Dry the seed on shade cloth on the grates of a shearing shed floor by turning the seed over twice a day for 34 days or until completely dry (to avoid the seed going mouldy)
8. Sow the seed as soon after drying as possible - on well drained soils into a scalp line; on poorly drained soils onto a mound when still dry in March
9. Weed control is not necessary on saline sites, but use a knockdown herbicide on non-saline sites prior to or immediately after seeding
10. Monitor and control red legged earth mite if necessary (as outlined in native plants)
11. Follow up weed control with a shielded spray

Perennial pastures

Lucerne

Success with lucerne outlines seven steps to success in establishing lucerne:

1. Control weeds in the years leading up to sowing by either cropping or spray topping (but don't use Group B herbicides - sulphonyl urea herbicides)
2. Check to see that the pH of surface and sub-soils is from 5-8; lime if from 5.0-5.5; ensure that there adequate P, K, S and trace elements; use gypsum on clay soils
3. Sow at least 4kg/ha of an appropriate variety of viable, certified, inoculated and lime pelleted seed
4. Ensure accurate seed placement (15mm for loams and up to 25mm deep for sands) and good seed-soil contact by the use of press wheels or a roller; non wetting sands can be established by sowing in furrows and/or applying wetting agents and/or clay spreading
5. Monitor and control insects such as red legged earth mite, lucerne flea and cutworm
6. Only use a cover crop if required for erosion control and use at a very low rate to avoid excessive competition for moisture and set up the seed boxes to keep the lucerne in different rows from the cover crop
7. Exclude grazing in the first year until flowering begins; or when plants wilt and begin to drop older leaves and ensure stock are removed before they begin to graze near the crown

Ensure that there is at least 250mm of stored soil moisture in the profile in the northern Murray Mallee.

Perennial veldt grass and evening primrose on deep sands

These key steps to successfully establishing a perennial veldt grass and/or primrose pasture are derived from *Well-adapted perennial grasses for the Esperance sand plain* and *Eight steps to successful perennial pasture establishment* include:

1. Minimum rainfall - 300mm for perennial veldt grass and 250mm for primrose
2. Control weeds such as silver grass and skeleton weed in the year prior to sowing by spray topping and spraying respectively and possibly cropping with cereal rye
3. A stubble or cover crop such as cereal rye or triticale is necessary to protect the area from erosion until the pasture establishes
4. Sow after a complete weed germination in autumn at 1 to 3 kg/ha of veldt grass (1 to 2 kg/ha of primrose) no deeper than 10mm
5. Consider sowing medic or possibly lucerne as a companion legume

6. Ensure good seed-soil contact
7. On deep sands, apply for the Northern Mallee - at least 7 kg/ha of N and 10 kg/ha of P eg 70 kg/ha of MAP; Southern Mallee and Murray Plains areas - 10 kg/ha of N and 10 kg/ha of P eg 55 kg/ha of DAP
8. Monitor for weeds and insects and control if required
9. Allow veldt grass to set seed in its establishment year before grazing
10. Rest the stand in spring to allow seed set
11. Graze rotationally and remove stock leaving 3-4 cm of leaf ensuring that fragile areas do not develop bare spots, for example, sheep being allowed to camp on them for any length of time - sandhills should be fenced off from other land capability classes where practicable

Further reading

Bartel B and Knight A 2000 *Oldman saltbush Farmer experience in low rainfall farming systems* Primary Industries and Resources SA, ISBN 0 7308 4399 8 - very usefully reflects on variances between the discouraging results of grazing studies on the value of saltbush and more positive farmer experiences, principles for design, establishment and management and a couple of financial analyses (24p glossy A4)

Bonney N 2003 *What seed is that?* Neville Bonney ISBN 0 646 19820 3 - well illustrated with a useful profile for 280 South Australian species including photos, seed collection and propagation hints; contact Neville nbonney@senet.com.au to obtain a hard copy for $68.50 or CD-ROM

Bowyer J 1998 *Well-adapted perennial grasses for the Esperance sandplain* Farmnote 11/98, Department of Agriculture, WA - describes perennial veldt grass (and others), the establishment and management at 'fact sheet' level; included on the enclosed CD-ROM

Dalton GS 1993 *Direct seeding of trees and shrubs A manual for Australian conditions* Primary Industries, SA, Adelaide, ISBN 0 7308 3947 8 - a most useful reference for anyone who is involved in direct seeding; very reasonably priced and available from State Flora and PIRSA

Field P 2002 *Mallee perennial pastures 2001/02* Victorian Department of Natural Resources and Environment/Mallee Catchment Authority - a report on a study using lucerne in the Victorian mallee to dry out soil profiles and includes excellent trial site information on soils and soil moisture; contact Peter Field at Swan Hill

Keys M and McDonald W 2002 *Eight steps to successful perennial pasture establishment* NSW Department of Agriculture, Agfact P2.2.6 - provides sound generic guidelines for pasture establishment; included on enclosed CD-ROM and the web address http://www.agric.nsw.gov.au/reader/past-establishment/p226.htm

Knight AJP, Beale PE, Dalton GS 1998 *Direct seeding of native trees and shrubs in low rainfall areas and on non-wetting sands in South Australia* Agroforestry Systems 39: 225239 - refereed paper outlining the trial results; try the Waite library

Lloyd D, English M, Williams R, McDonald and Auricht G 2002 *Lucerne pests and disorders The ute guide* Grains Research and Development Corporation, AGDEX 121/630 - one of the easy-to-use *Ute guides* and a 'must-have' for those involved with growing lucerne; available from PIRSA for less than $30

McDonough C 2003 *Measuring the moisture that your crops can extract from your paddocks* Draft guidelines, Mallee Sustainable Farming website www.msfp.org.au, Rural Solutions SA, Loxton - outlines method to measure stored moisture which is necessary for selection of lucerne trial sites

MMLAP (undated) *Revegetation Fact Sheet Series: Wood and products; Fodder; Shelterbelts; Enhancing remnants; Protect remnants and Local native species* Mallee Futures Program - useful introductory fact sheet series available in hard copy and from http://lm.net.au/~murraymalleelap/

Stanley M, Britton R and Christinat R 2002 *Success with lucerne* PIRSA Publishing Services - a definitive publication comprehensively covering establishment and management and including proformas for paddock records; available from PIRSA for approximately $55

The approach

When considering the merit of establishing perennial vegetation, most farmers will consider the immediate out-of-pocket expenses and will also have a strong sense of foregone agricultural production (agricultural opportunity cost) - especially if the proposed area is good cropping land and large in size.

Well-informed decisions on different revegetation options need to be influenced by the farmer's:

- Short and long-term income requirements
- Availability of on-farm labour over time
- Consideration of impact on the property value
- Willingness to take calculated risks

Looking at these factors on a whole-of-farm scale, rather than paddock-scale is very powerful - the implications are much harder to ignore. For example, if:

- 10% of a 1500ha farm was revegetated with local native species for shelter and wildlife corridors
- the average Gross Margin for the property is $75/ha
  (class IV land might typically be approximately $50/ha and class III land $100/ha)

the loss of income from the area revegetated would be $15,000 every year, $125,000 over ten years and $1,250,000 over 100 years - so much for the cost of fencing being the prohibitive cost!

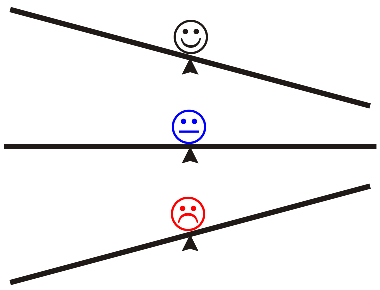
Tom Yeatman's *2004 Farm Gross Margin Guide - A gross margin template for crop and livestock enterprises* provides a comprehensive set of information that incorporates sensitivities to yield and price as well as providing charts of historic prices and returns.

The indicative average GMs used in these *Guidelines* generally range from $19-100/ha and up to $150/ha for the best cropping land, and are derived by conservatively interpreting Tom's mid-range figures by erring on the side of lower yields and prices.

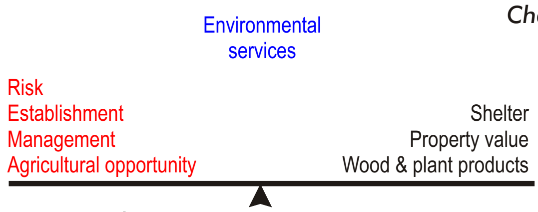
Prime lambs	$26/DSE
Wool - SR merino ewe	$34/DSE
Wool - wether	$19/DSE
Wheat - APW	$200/ha
Wheat - Durum	$400/ha
Barley - Malting	$400/ha
Barley - Feed	$300/ha
Oats Milling	$140/ha
Oats - Feed	$100/ha
Oats - Export hay	$350/ha
Field Peas	$120/ha
Triticale	$40/ha
Canola	$300/ha

There's hardly any need to get 'hung up' about discounted cash flows and 'real' net operating profits - the cumulative Gross Margins (GM = total enterprise revenue less operating costs) of each farm enterprise largely represent the return for the farmer's effort and how much there is to pay farm overheads and put food on the table etcetera. Reductions in farm production and revenue are as real as a pay cut to an employed person - regardless of the inherent fluctuations in farm revenues.

Calculating the establishment, management and agricultural opportunity costs is much easier than accurately forecasting the value of any on-farm benefits of using perennial vegetation. But that doesn't matter all that much, because knowing what the project owes for the duration of the project provides the basis for reflecting on what increase in primary production is needed to at least offset the costs.



Change in farming system viability



Costs...and...returns

This approach of checking to see what benchmark level of productivity is needed to achieve a net improvement to the farming system is applied in this section to native species blocks, buffers and corridors, saltbush blocks and alley systems, perennial pastures, shelterbelts and broombush and firewood blocks. The next step is to draw on collective knowledge and experience and reflect on the prospects of increasing productivity to surpass the benchmark.

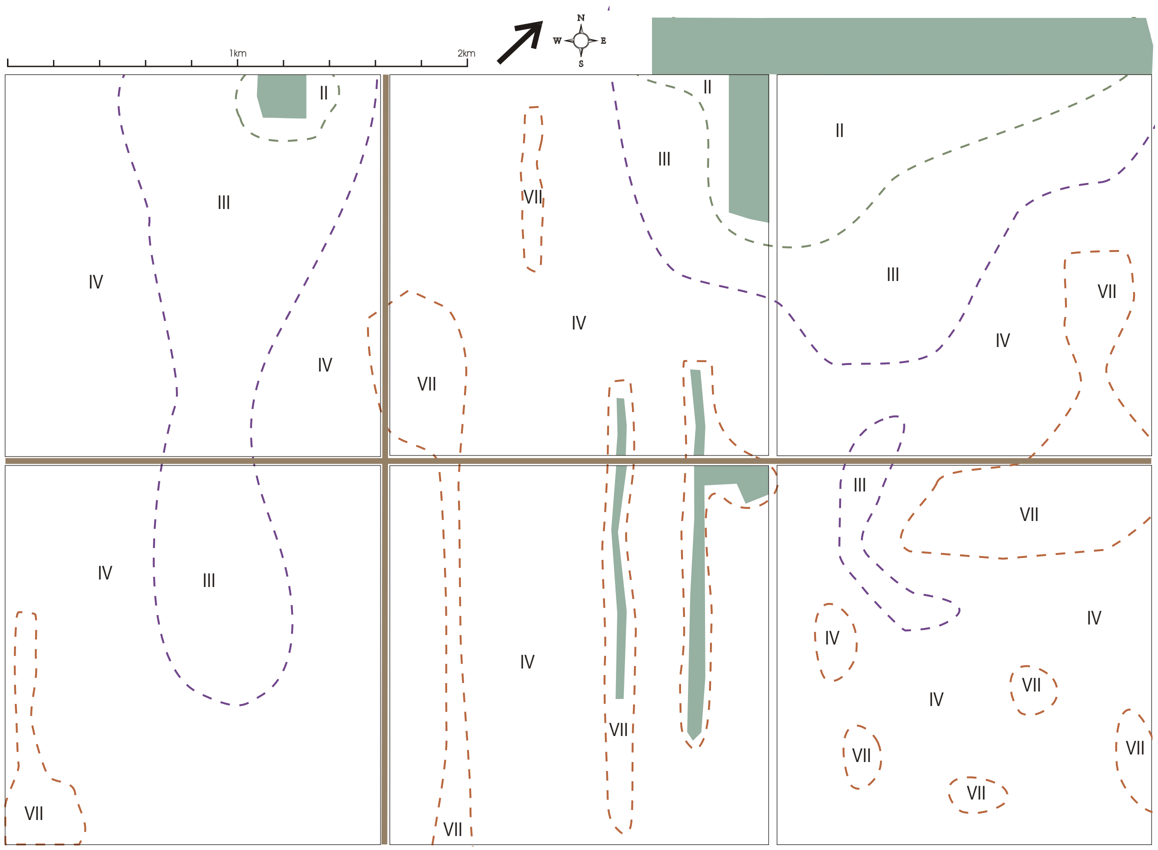
Some options may do, some are 'touch and go' and others may fall 'short of the mark' - all in all, providing the basis for sound decisions and sensibly refined designs according to 'your' set of values as outlined in *Using the guidelines*.

More information on economic methodology can be found on pp20-25 of *Forestry as agriculture NW region Vic.pdf* on the included CD-ROM. Also see the box *Factoring in the 'wait time'* on page 59.

As indicated above, 'integrated tree processing' industries that incorporate products such as biomass, extractives, activated charcoal and industrial feedstock for wood composites are still very much in the 'blue-sky' realm. Much needed research is evaluating species, products/markets, production and processing systems and the viability relative to existing agriculture as outlined in *Emerging products and services*.

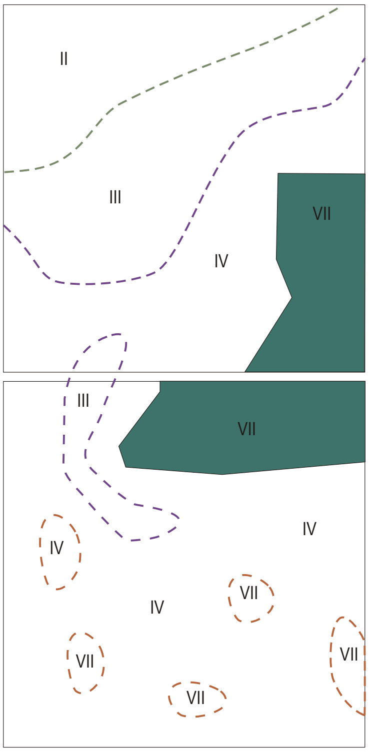
A hypothetical 1500ha 'case study' property provides the focus for the analyses by showing the options in a farm context to 'bring the concepts to life'. The base plan incorporates:

- Six 256ha sections with an average paddock size about 60ha (note that fencing is not shown but should be located based on land capability classes)
- Some roads are well used by the public and others restricted to on-farm use
- The key Murray Mallee land capability classes based on wind erosion
- Parallel and jumbled dunes
- Some remnant native vegetation



The following analyses may at first appear formidable, but **be reassured - YOU only need to know your farm Gross Margins and have a calculator and a spare beer coaster** without any writing on the back. **Every situation is different** in terms of stocking rates, Gross Margins and land types, **so you are strongly advised to do your own analysis** - support for property management planning and financial analysis is available from advisory officers and consultants.

Note that on page 52 you can find more information on a range of modelling tools included on the CD-ROM in these *Guidelines*, including *Beer coaster calculator.xls*!



Native species blocks, buffers and corridors

Revegetating the deep infertile sands of the relatively unproductive and troublesome class VII land in the eastern sections could provide habitat and permanent stabilisation.

The southern block is approximately 40ha in area, just large enough for mammals to inhabit, especially if complemented by the 36ha northern block.

The agricultural opportunity cost of periodically sowing rye or triticale to stabilise the sand, provide some light grazing and reap some grain, is far less than the better cropping areas but surprisingly, it still adds up over the years. Based on an average GM of $40/ha for triticale (@1.5t/ha) one year in five and grazing of unimproved annual pastures that support 1DSE/ha at $19/DSE, the foregone agricultural production totals $35,000 over 20 years. Note that the breakeven point for triticale is approximately 1t/ha.

The cost of establishment based on $500/ha for direct seeding would be $38,000 and with 2.5km of cyclone fencing materials for both blocks might cost approximately $6000.

It is hard to argue that the total cost of $79,000 over 20 years is anywhere near offset by tangible favourable impacts on adjacent agricultural production. The discussion below on shelter needed to warrant investment in shelter systems will provide a perspective on the potential value of shelter. It is hard to imagine revenues from providing bee keepers with access or savings from the cost of renting hives for pollination of lucerne to be more than 'beer money' relative to the costs.

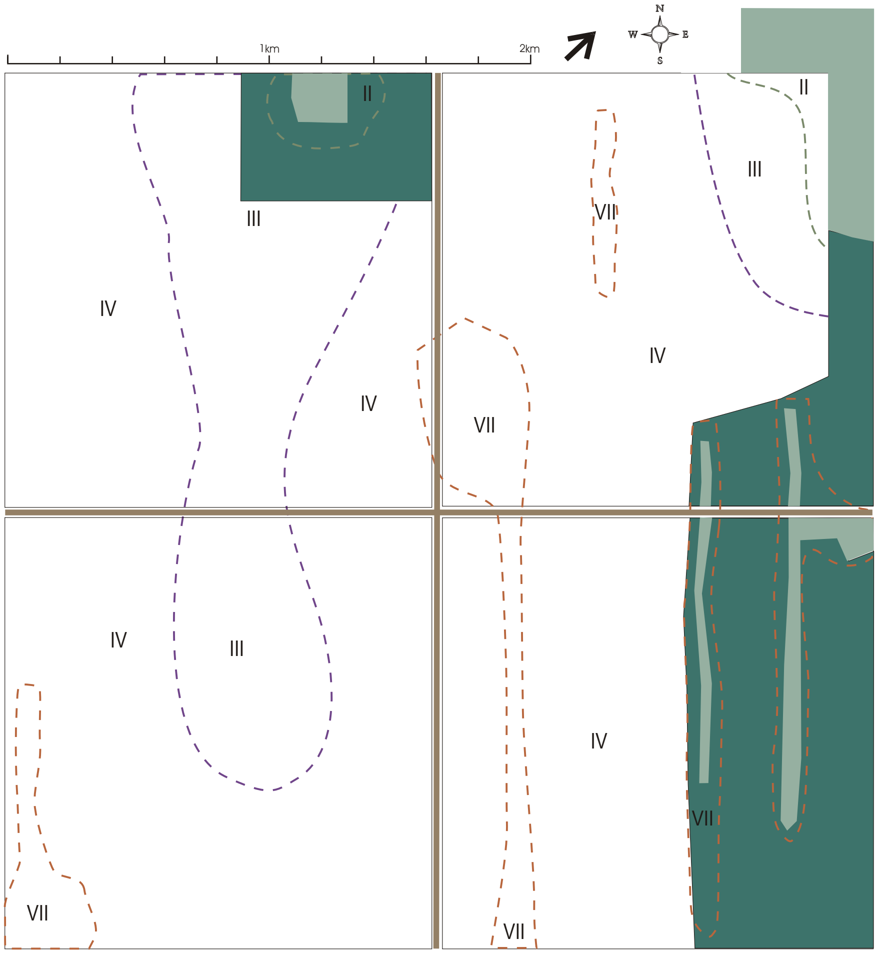
The effect of this project on property value is more likely to be negative than positive on current markets.

- The case for revegetation might be more compelling if:
- The area needs major earthworks and there is a constant drain on resources for resowing
- GMs are negative, even with high inputs and grazing revenues are lower
- The area is a high priority for biodiversity conservation (but dune vegetation communities are better represented than those on the inter-dunal flats) and public funding is available to cover all out-of-pocket costs

Blocks of local native species on the better cropping land may have a greater conservation value, but the opportunity cost is far greater.

The 30ha NW revegetation block beautifully buffers the 4ha of remnant native vegetation with the poorly represented vegetation communities of the loamy flats, but with a GM of $100 and $150/ha, the agricultural opportunity costs over 20 years work out to be $60,000 and $90,000 respectively. Such impacts on farm cash flows are very real and become major decisions that need to balance the biodiversity benefits with such costs.

The 30ha NE and 90ha SE revegetation corridor and blocks are mainly located on less productive land capability class IV land. Based on a GM of $50/ha, the corresponding agricultural opportunity cost for only one generation (20yrs) calculates to $30,000 and $90,000 respectively.



The present value of these future GMs may be much lower, but public purchase of key land parcels for a one-off cost of a few hundred dollars per hectare would seem to be a more equitable approach for where there is an imperative for block revegetation and major corridors.

Roadside revegetation is a different proposition (see *Shelterbelts*).

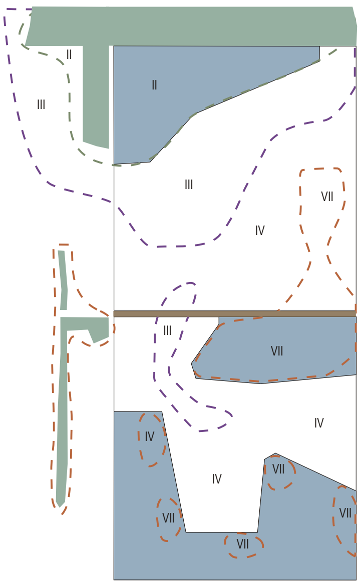
Saltbush foliage

Saltbush blocks and alleys

Saltbush is a more productive alternative to revegetation with local native species. The question though is 'What total production is needed to warrant the investment in establishment, and fencing agricultural opportunity cost?'

Very productive saltbush on relatively fertile sands near Swan Reach

The diagram shows a 56ha block of saltbush 'cell grazing' on the shallow stony class II ground in the north, a 40ha block on deep infertile class VII sands and a 72ha block on jumbled dunes to the south (classes IV and VII).



For the **block of saltbush on the 40ha central block of class VII land**, the same one that was considered for local native species:

- The opportunity cost might be $19,000 over 20 years
- The establishment cost might be $12,000 (40ha @ $300/ha; ~$360/ha using a contractor based on 21 cents/seedling and a plant density of 1700/ha)
- Fencing into 6ha cells might cost $7500 (3km @ $2500/km)
- Providing watering points might cost ($1900 for 1km poly piping & 6 new troughs)
- Supplementary feeding might cost $48,000 (at 0.5t/ha/yr @ $120/t based on thirty big round 330kg bales over 20ha over six weeks)
- Periodically fertilising would be essential for healthy productive saltbush on the typically infertile deep sands (see discussion on nutrition page 49) and might cost $7200 ($30/ha every three years or so)
- Periodically cutting the saltbush to keep it fresh and below grazing height might cost $3600 ($15/ha every three years)
- Extra water might cost $6300
- Such costs total approximately $105,000

Note that just as for revegetation using local native species, such deep dune sites **must** be stable prior to establishment and the technique used needs to ensure that the area does not become more vulnerable to wind erosion.

This table outlines the assumptions set out above. You can use the spreadsheet file *Beer coaster calculator.xls* to change the blue figures to suit your circumstances.

Also included in the 'model' is the assumptions on Gross Margins eg $20/DSE* and the calculation of the agricultural opportunity cost (not shown here).

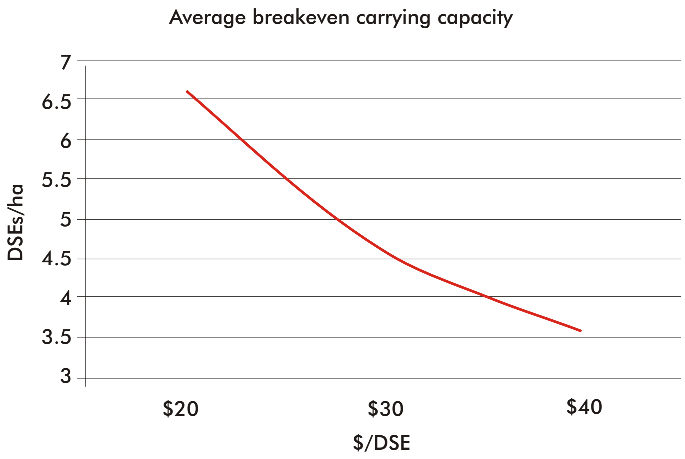
*A DSE or dry sheep equivalent is the nutritional requirement of a 50 kg dry (ie. non-lactating) sheep. This enables different classes of animals to be compared on a common basis.

Just getting $105,000 worth of production as GMs over 20 years would provide a zero rate of return not the basis for borrowing money. Based on $20/DSE, the carrying capacity would need to be approximately 6.6 DSEs/ha. If the farmer is confident of carrying say 89 DSEs/ha or better, it would seem to be worth looking into further.

Saltbush block		
Project length	20	yrs
Area	40.0	ha
Fencing	3	km
Fencing	$7,500	total
Extra troughs #s	6	one existing trough
$/troughs	$317	inc reticulation
Trough cost	$1,900	
Est cost	$300	/ha
Est cost	$12,000	total
Supplementary feeding cost	$120	/t
T/ha	0.50	
Supplementary feeding cost	$60	/ha/yr
Supplementary feeding cost	$48,000	
Fertilising cost	$30	/ha (40kg DAP plus $10/ha app)
Fertilising frequency	3	yrs
Number of apps	6	total
Fertilising cost	$7,200	total
Cutting cost	$15	/ha (machinery cost only)
Cutting frequency	3	yrs
Number of cuts	6	total
Cutting cost	$3,600	total
Ag opp cost	$19,000	
Sub total cost	**$99,000**	
DSE/ha	6.2	for approx breakeven only
Extra water	1100	L/yr/DSE
Water cost	$0.95	
Extra water cost	$6,466	
Grand total cost	**$105,000**	
DSE/ha	6.6	For breakeven

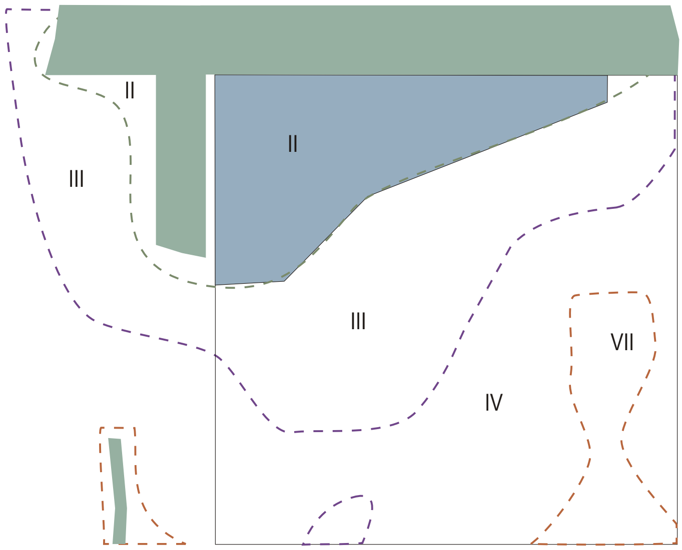
Alternatively if the GM per DSE increased, the proposition becomes much more attractive.

Increasing the GM to $30/DSE and $40/DSE reduces the breakeven carrying capacity from 6.6 to 4.6 and 3.6 DSEs/ha respectively.



Very similar levels of production would be required on the shallow stony northern block. Such productivity would be nothing short of miraculous on unbroken sheet calcrete highlighting the importance of uncovering a number of small transects of calcrete in the paddock in question before large-scale investment in saltbush.

The photos illustrate a saltbush planted over sheet calcrete with survival and productivity dependent on roots finding the solution hole as illustrated or cracks in the calcrete



Some may be confident of such 'benchmark' levels of productivity - others are less so. Talking to farmers who are growing saltbush in comparable circumstances seems fundamental - to find out if their productivity surpasses such a 'benchmark' or not.

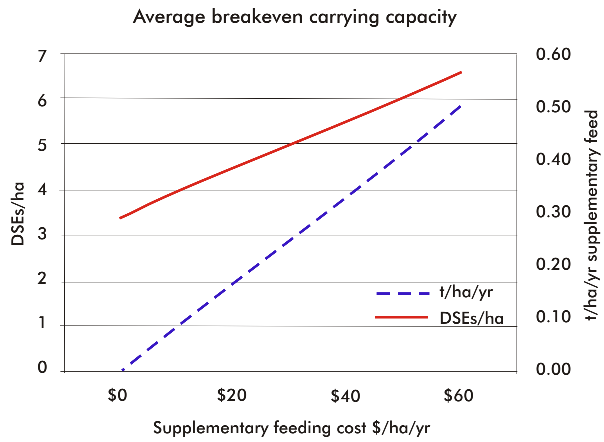
It is worth looking at the effect of the cost of supplementary feeding on the breakeven carrying capacity.

The graph illustrates that a system with all 'supplementary' feed provided between widely-spaced rows and/or from adjacent paddocks only needs to carry 3.6DSEs/ha in contrast to 6.6DSEs/ha for 0.5t/ha/yr of hay at $120/t.

One farmer uses straw at $30-40/t.

Healthy productive saltbush on fertile sands near Swan Reach

Stressed insect-infested saltbush on shallow stony soils near Taplan



It becomes more of a design issue, but wider spacing might reduce establishment costs and eliminate the need for supplementary feeding.

The six metre spacing between two closely spaced rows is at least a move in the right direction.

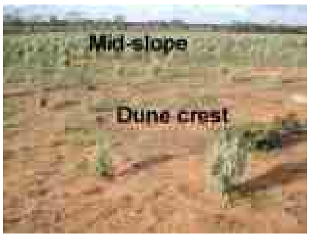
Another way of looking at viability however, is by **comparing the value of saltbush fodder reserves with the cost of expensive feed required during autumn-feed-gap** to maintain a flock without saltbush. Such an analysis could simply involve estimating the extra cost of hay/grain needed to maintain a flock over the autumn feed gap for 10-20 years or so, to include a drought or three, and comparing that with the cost of establishing and managing enough saltbush to maintain the same flock.

The 40ha is supporting a flock of 235 DSEs based on the breakeven point of approximately 6 DSE/ha at a cost of $4700/yr. This equates to $20/DSE and provides the basis for comparing with the value of supplementary feed that could be afforded in lieu of the saltbush. This could buy 200kg/DSE of hay (at $100/t) or 80kg/DSE of grain (at $250/t). The *Gross margins* book seems to infer that normal feeding rates are about 15kg/hd of grain and/or 25kg/hd of grain.

Only if there are good prospects for healthy saltbush surpassing a production 'benchmark' might discounted cash flows (*Net Present Values* and *Internal Rates of Return*) be warranted to compare and refine design options.

The **keys to saltbush health** are:

- Nutrition especially on deep sands
- Soil moisture holding capacity especially root accessibility through calcrete to sub-soils for shallow soils



Illustrations of the effect of fertility on survival and productivity of saltbush

The photos (left) plus the observations by Ray O'Malley from Karoonda of healthy (insect resistant) vigorous saltbush on sites with a history of prior legume crops and applications of manure make a compelling case for adequate nutrition, nitrogen in particular. This maybe so, but what productivity response is needed to warrant regular applications of fertiliser?

Very simplistically, spending approximately $30/ha for say 40kg/ha of DAP fertiliser every three years only 'owes' about 0.5 DSEs/ha at $20/DSE, so if you actually expected to increase carrying capacity by at least 0.75-1 DSE/ha, there would be a strong case for the 'investment'.

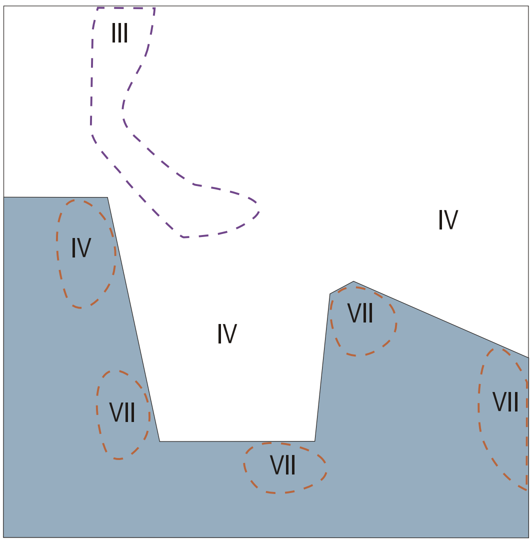
Foregoing fertiliser application is bound to tempt the frugal. To actually be better off financially, productivity could only drop by 0.5 DSEs/ha or so from the 'benchmark' which includes fertilising - any more, and that would be a poor economic decision.

Mike Krause applies a more rigorous economic methodology and looks at the effect of changes in the wool price and the cost of additional water requirements. The breakeven point works out to be a carrying capacity of 6 DSEs/ha but supplementary feeding costs are not included.

Appendix 2 of the publication *Oldman saltbush - Farmer experiences in low rainfall farming systems* summarises SALLY, a model evaluating the effect of saltbush on farm productivity. For more information, contact Helen Lamont from Rural Solutions, SA.

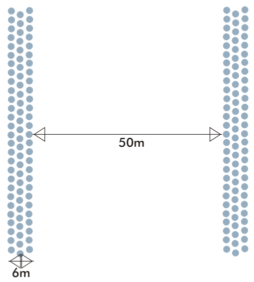
Improving the pasture with lucerne, primrose or veldt grass would reduce groundwater recharge and so long as the paddock is crash-grazed, such perennial pasture species need not be damaged from overgrazing.

Alley systems are an option for the 72ha of class IV and VII **jumbled dunes in the southern block**. Belts of saltbush with alleys of agriculture might provide enough protection to acceptably minimise risk of wind erosion during grazing and cropping rotations - especially if the alleys were narrower or blocks were planted on the class VII land. The same fertility constraint and pasture-mix management issues as outlined above apply, and need due consideration.



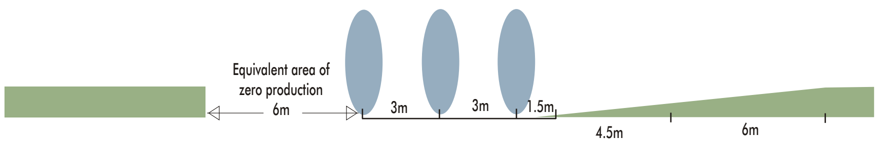
One of the key issues with alley farming systems is the edge effect on crops and pastures. Higher GMs of crops in comparison with pastures, results in a higher agricultural opportunity cost than is the case for when only grazing is displaced.

Competing saltbush roots can be severed by deep ripping, but that incurs an additional periodic cost and has not been found to be effective on ***tree*** species in deep sandy soils by WA researcher Rob Sudmeyer.



Let's do some sums for a design that has 6m-wide three-row belts of saltbush with 50m-wide alleys and take a similar approach of finding the increase in production required to break even with the agricultural opportunity cost plus the cost of establishing and managing the saltbush belts.

There would be 12.9 km of belts directly occupying 11.6 ha (3 rows x 3m = 9m x 12.9km = 11.6ha) of the 72ha area. Now if the saltbush roots competing with crops and pastures had a total 'equivalent zero production distance' from the saltbush of 6m (see diagram below), that would increase the total area of displaced crops and pastures to 23.2ha. Based on 70% of the land as class IV with an average GM of $50/ha and the balance as class VII with an average GM of $23/ha, the associated agricultural opportunity cost over 20 years would be $45,000.



The saltbush would need fencing into two approximately 6ha blocks and provision of an extra watering point so the saltbush could be more easily crash-grazed in six weeks or less without needing huge flocks of sheep. So including these in the cost of establishment and management, the cost totals $59,000.

Saltbush alleys

Project length	20	yrs	Fertilising frequency	3	yrs
Area	72	ha	Number of apps	6	total
Inter-row spacing	3.0		Fertilising cost	$2,400	total
Number of rows	3		Cutting cost	$15	/ha (mach cost only)
Distance to fence	0		Cutting frequency	3	yrs
Width of pin	6		Number of cuts	3	total
Distance between belts	50		Cutting cost	$500	total
Length of belts	12900	m	Root span for equiv zero	4.5	m
Width of belts	9	m	prod'n	4.5	m
Area of saltbush	11.6	ha	Root span outside 2nd	11.6	ha
Est cost	$300	/ha	length	23.2	ha
Est cost	$3,500	total	Additional area	$23	30%
Fencing	0.4	km	Total affected area	$129	70%
Fencing	$1,000	total	Av GM class VII	$97	
Extra trough #s	1	one existing trough	Av GM class IV	$45,00	
$/trough	$650	inc reticulation	Av GM	0	
Trough cost	$650		Ag opp cost	$53,00	approx breakeven
Supplementary feeding	$120	/t	Sub total cost	0	only
cost	0		DSE/ha	6	L/yr/DSE
T/ha	$0	/ha	Extra water	1100	
Supplementary feeding	$0		Water cost	$0.95	
cost	$35	/ha (40kg DAP app)	Extra water cost	$6,277	
Supplementary feeding	20	yrs	Grand total cost	$59,00	for breakeven
cost	72	ha	DSE/ha	0	yrs

On this basis, the grazing productivity from the area occupied by saltbush would need to be approximately 7 DSEs/ha to just get the money back or roughly 9 DSEs/ha to warrant pursuing further. Note that consideration is given in the *Shelterbelts* section below to quantifying the value of increased productivity from provision of shelter.

Planting out the class VII jumbled dunes more as blocks and carefully cropping the class IV land would reduce the overall agricultural opportunity cost and may have more merit.

The *Low rainfall alley farming model* developed by Doug Young and Melissa Bright is included on the enclosed CD-ROM. The model user specifies inputs configuration data, species, agricultural rotation, establishment and maintenance; the model user can edit underlying assumptions on gross margins, cost, yield, values and shelter benefits. The model calculates foregone production, wind erosion benefits, livestock effects, fodder value and timber value, but there seems to be an error in advancing revenues beyond 15 years in the cash flow as needed for timber/wood options.

Also on the CD-ROM are spreadsheets used for costing projects (*Cost estimator.xls*) and benefit cost analysis (*Benefit cost calculator.xls*) by Greg Dalton, plus REVAL (*R*evegetation *EVAL*uation Model) that applies similar methodology used in these *Guidelines*, but with the sophistication of discounted cash flows.

Finally however, just using the simple spreadsheet file (*Beer coaster calculator.xls*) on the enclosed CD-ROM (or even a calculator, a pencil, rubber and the back of a real beer coaster) with assumptions that are meaningful to a farmer who is considering saltbush should greatly help deciding whether a 'yay or nay' to an investment in saltbush makes more sense.

Carrying capacity of saltbush farmer experiences

Forecasting the carrying capacity of saltbush for a prospective project is fundamental to assessing the project's merit. The following anecdotal experiences may provide a starting point for reflection and closer future monitoring and assessment.

Adrian Stoeckel near Swan Reach   7.7 DSEs/ha   0.60.8t/ha

'1000 sheep per 50ac block for 8 weeks (20 ha ie 50 sheep/ha * 8/52 = 7.7 sheep/ha/yr/grazing cycle); equivalent to 3 sheep per acre for a full year; 34t of hay per week for 8 weeks in 100ac block (2432t per 40ha = 0.60.8t/ha)'

Ray O'Malley near Karoonda   8 DSEs/ha 2 grazing cycles   0.5t/ha/grazing

'700 sheep in 50ac for 6 weeks (20 ha ie 35 sheep/ha * 6/52 = 4.0 sheep/ha/yr/grazing cycle); 5 big round bales per week over 6 weeks = 30 (10t at 3 bales/t = 0.5t/ha for 20ha); grazed 23 times/yr'

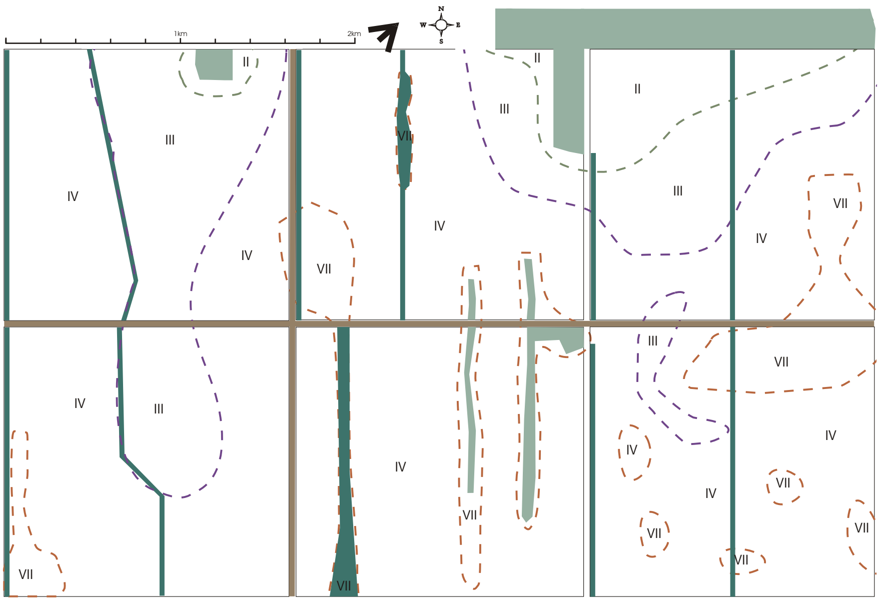
Peter Kroehn near Waikerie   >3 DSEs/ha/grazin   <0.2/ha

'300 **ewes** per 30ac ie 100 sheep per 10ac for 6 weeks (4ha ie 25 sheep/ha * 6/52 = >2.9 sheep/ha/yr/grazing cycle); plus one big bale per week ie 6 big round bales in total over 6 weeks grazing (2t at 3 bales/t = <0.2t/ha for 12ha); can be grazed every 7 months pending seasonal conditions, but only grazed once a year-in autumn'

Shelterbelts

See what you think of the shelterbelt design below with regards to the orientation, alignment with land capability class boundaries, impact on fencing costs and paddock sizes and exacerbated risk of wind erosion in the root competition zones. Each of these aspects has a 'problem' that might reveal itself to you if choose to take a close look.

There's 17km, or thereabouts of belts 7-9m tall sheltering a band about 70-90+ metres into the paddocks - sheltering a total area of approximately 136ha or 9% of the property. Three-row 12m-wide belts would immediately displace approximately 20ha and if root competition resulted in a 6m band of equivalent zero production (as described in alley farming section above), the total area of displaced agriculture becomes approximately 30ha.



The GMs of the agriculture displaced may vary markedly between capability class III and VII land, but based on an average of $50 and $100/ha over a 20 year project the agricultural opportunity cost is approximately $30,000, and $60,000 respectively. Now it will take some time for the roots to occupy the full 30ha, but it will take longer before the belts achieve a near mature height of 8m.

The key question is 'Are the shelter benefits likely to match the agricultural opportunity and establishment costs?' But, whilst recognising the variety of GMs, shelterbelt widths and fencing needs, let's avoid introducing unnecessary complications for this rudimentary analysis.

If fencing was only needed on one side and fences were progressively erected with on-farm labour, based on $2500/km but may be less for materials depending on the construction, the total fencing cost would be approximately $45,000. The establishment cost based on $500/ha would be $10,000.

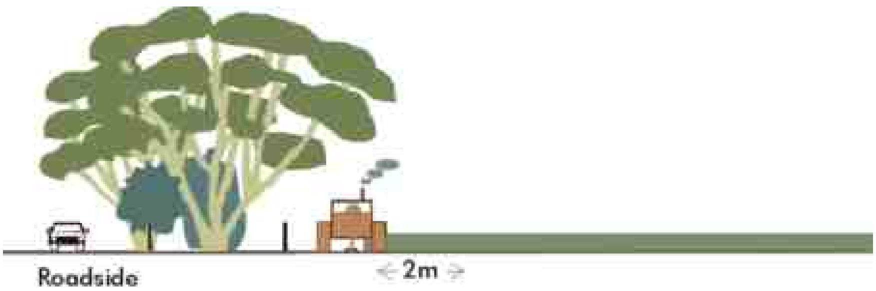
Now with total costs tallying from $85,000-$115,000, the next question is roughly 'What percentage shelter response would be required to get our money back for each of the average GM scenarios?'

The cumulative 'unprotected' GMs ($50 and $100/ha) for the 'sheltered area' (136ha) total $136,000 and $272,000. The prospects of achieving 42-63% increases in GMs is clearly nonsense, but don't lose heart.

Av. GMs/ha	Estab cost	Ag opportunity cost	Total cost	Ag prod'n in sheltered zone	Value of production needed to recoup investment	Percentage increase
$50	$55,000	$30,000	$85,000	$136,000	$221,000	63%
$100	$55,000	$60,000	$115,000	$272,000	$387,00	42%

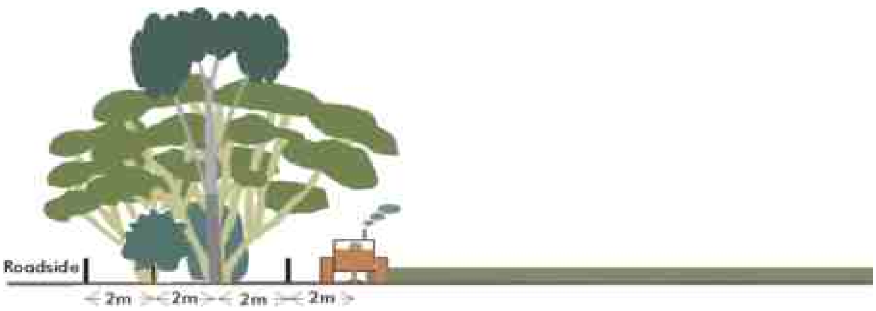
Decreasing the shelterbelt width, increasing the height, producing wood and plant products and establishing shelter on the roadside all decrease the order of magnitude of the shelter response required.

Decreasing the shelterbelt width to a closely-staggered two-row belt and periodically ripping roots in soils with a clay subsoil incurs a small increase in management costs but markedly reduces the establishment and agricultural opportunity costs to $13,500, $27,000 and $41,000. Needing a 30-50% shelter response is moving in the right direction but still clearly unrealistic.



Av. GMs/ha	Estab cost	Ag opportunity cost	Total cost	Ag prod'n in sheltered zone	Value of production needed to recoup investment	Percentage increase
$50	$55,000	$13,000	$68,500	$136,000	$204,500	50%
$100	$55,000	$27,000	$82,000	$272,000	$354,000	30%

Increasing the height by including species such sugar gum and flat-topped yate on suitable sites can be expected to achieve at least an extra 2m in height increasing the area sheltered by 25% to 170ha. The required shelter response is still 'moving in the right direction', but no where near far enough with required shelter responses of 24-40%.



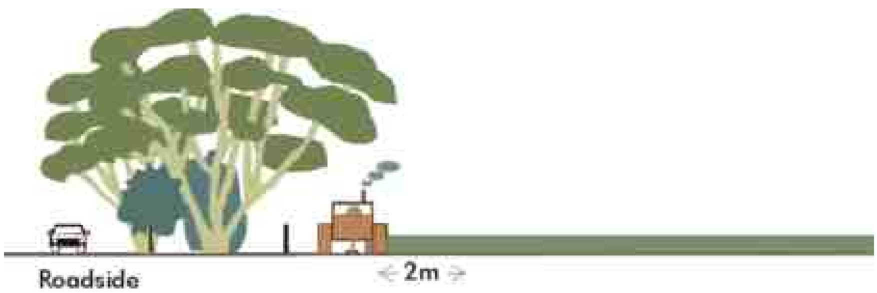
Av. GMs/ha	Estab cost	Ag opportunity cost	Total cost	Ag prod'n in sheltered zone	Value of production needed to recoup investment	Percentage increase
$50	$55,000	$13,500	$68,500	$170,000	$238,500	40%
$100	$55,000	$27,000	$82,000	$340,000	$422,00	24%

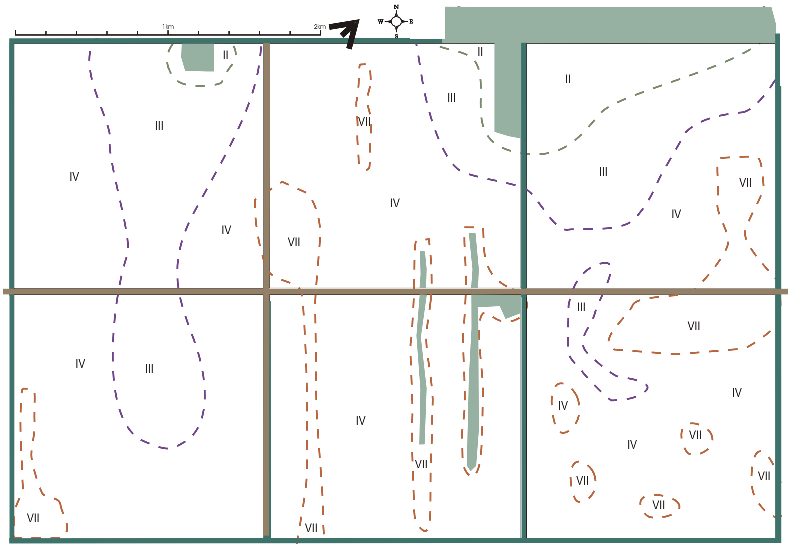
Harvesting firewood at the end of the 10ha, 20yr project could be expected to produce from 200-600t based on 13t/ha/yr. Delivered to the Adelaide woodyards, wood is fetching more than $130/t. Out-of-pocket expenses should be less than $30/t leaving $20,000$60,000 as a GM. Note that if the harvesting and marketing took 2 hours per tonne, this would require 50-150 days of on-farm labour (equivalent to an average of 2.5-7.5 day/yr). Based on $40,000 wood revenue, the shelter response required ranges from 12-17% still implausible.

Av. GMs/ha	Estab cost	Ag opportunity cost	Total cost	Ag prod'n in sheltered zone	Value of production needed to recoup investment	Percentage increase
$50	$55,000	$13,500	$68,500	$170,000	$198,500	17%
$100	$55,000	$27,000	$82,000	$340,000	$382,00	12%

Using broombush as an understorey component could increase total income.

With **shelterbelts on roadsides** there may not need to be any fencing costs or any significant agricultural opportunity costs. Approximately $6,000 is 'all' that is needed to plant 20 km of roadsides with local native species - good for conservation as well as farm shelter.





Av. GMs/ha	Estab cost	Ag opportunity cost	Total cost	Ag prod'n in sheltered zone	Value of production needed to recoup investment	Percentage increase
$50	$5,000	$0	$5,000	$136,000	$141,000	4%
$100	$5,000	$0	$5,000	$272,000	$277,00	2%

Now we're talking

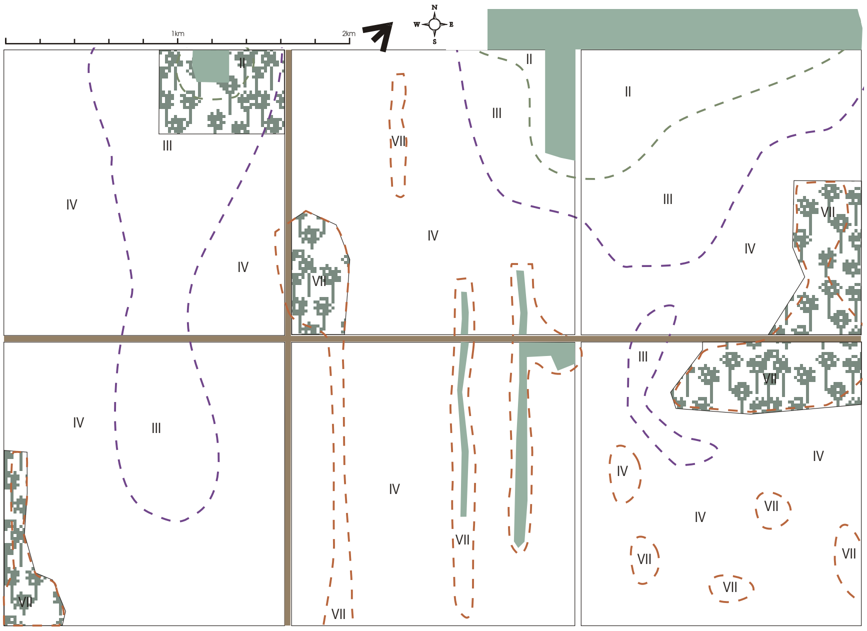
Excellent recent Australian research results on crop responses to shelter are summarised in *Shelter systems - What are they worth?* and the section *Design principles*. They clearly indicate that these sort of responses are more than realistic - even with ripping costs included and the wait time until full shelter benefits are realised.

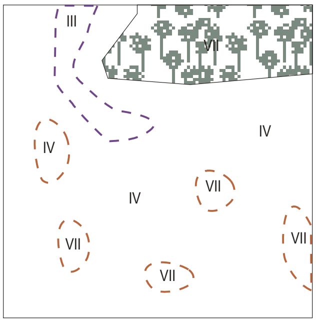
Hopefully your mind will be starting to think about some of the more subtle differences between growing conditions on various sites and smarter more-refined designs, but the compelling **take-home messages** are to:

- Invest in roadside shelter systems that protect the most productive cropping land as a priority and reduce root competition by ripping unless the soil profile is a deep sand
- Consider growing wood and plant products in internal shelterbelts on non-arable land after key roadsides are revegetated
- Avoid displacing productive cropping land with even narrow shelterbelts, let alone three-row or wider belts unless there is a compelling biodiversity or land management imperative

Product blocks firewood and broombush

There are five 'product blocks' illustrated below - four on land capability class VII and one mainly on more productive class III land.





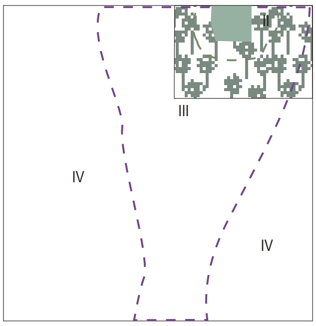
For the **40ha block to the south-east on class VII land**, the same one that was considered for local native species and saltbush:

- The agricultural opportunity cost might be $19,000 over 20 years
- The establishment cost might be $20,000 (40ha @ $500/ha)
- 1.5km of fencing might cost nearly $4000
- With costs totalling $43,000
- There might be 800-1200 tonnes of **firewood** (40ha growing modestly on the deep infertile sands at 1.0-1.5 t/ha/yr over 20 years) but still worth $80,000-$120,000 ($130/t less $30/t out-of-pocket expenses)
- Leaving a Gross Margin of $37,000-$77,000 for 200-300 days work (10-15 days/yr) less the time that would have been required for the triticale and grazing management

This equates to an increase in the non-discounted GM of nearly $50-100/ha/yr (in addition to the $23/ha/yr from the grazing/triticale) and seems worth closer consideration - at least as a 'drought-proofing measure' as an alternative to seeking a job off the farm.

Broombush could be grown and ready for harvest in the same time frame. Even if seedlings were efficiently propagated, the higher planting density required to produce well-formed marketable brush would increase the establishment cost to at least $1000/ha (4500 seedlings at $0.20 = $900). That would increase total costs to $63,000.

Brush is fetching from $7-12 per 20kg bundle delivered to market (Adelaide, Lameroo and the Wimmera). Bringing in a brush cutter and incurring a $5/bundle cost or thereabouts would leave too little left over for the grower. But if the brush is cut using on-farm labour and allowing $1/bundle for out-of-pocket expenses, there would need to be approximately 140-260 bundles/ha for a zero rate of return (get your money back). These sort of yields are reported from cutting mixed remnant native vegetation - yields are potentially considerably higher in plantations.



What about planting **a 'product block' in the productive north-western land capability class III cropping paddock?**

An increase in firewood yield to approximately 1.5-2.0 t/ha/yr (worth $120,000-160,000) would not be as attractive.

The agricultural opportunity cost increases from $19,000 to $80,000 based on a $100/ha GM and costs total $104,000 - leaving a surplus of $16,000-$56,000.

Just as GMs allow comparisons of the relative returns for on-farm input between enterprises, the GMs for product blocks largely reflect the value of the farm labour. For example, the $37,000-$77,000 for 200-300 days work for the firewood block on the class VII land equates to approximately $185-$255/day.

Note that if the wood was sold 'on the stump' with no farm input, only $10-25/t could be reasonably expected in today's market. That would result in only $8000-$30,000 - not even matching the costs. This is why well-informed urban investors would never contemplate growing firewood in the mallee - the cheaper land does not begin to offset the much slower growth rates than achieved in higher rainfall areas.

Factoring in the 'waiting time'

The other thing for any investor to do is to 'factor in' the 'waiting time' - the time that it takes for the revenues to offset the immediate out-of-pocket costs and progressively foregone agricultural income. It is possible to let the 'necktop computer' do it for you. For example, if someone pinned a $100 note on the ceiling and said you could have it in 10 years if you gave that person some money now, what would you offer?

$.........

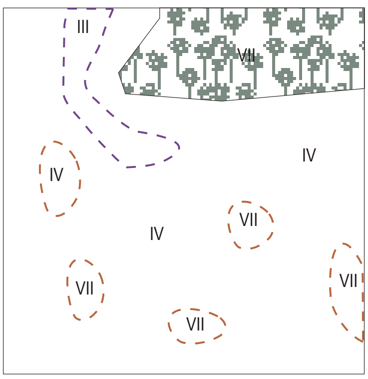
Answer'

If you offered $100 that would be a zero rate of return as indicated throughout this section as the 'breakeven points' - it would not be sensible to take a risk and incur a waiting time for no gain.

If you offered $50, you would be doubling your money, and that would be equivalent to putting $50 in the bank at an interest rate of 7.2% for 10 years. If you had to wait 20 years for the $100, the interest rate would be 3.5%

As indicated earlier, working out the rate of return (interest rate) by 'discounting cash flows' generally only becomes worthwhile when you have meaningful cash flow forecasts that you have confidence in, forecasts that look promising in terms of significantly greater income than costs and you want to compare and refine options, especially if over different time frames.

Information on *Internal Rates of Return* and *Net Present Values* have deliberately excluded to avoid unnecessarily complicating these analyses. Such information can however be found on pp20-25 of *Forestry as agriculture NW region Vic.pdf* on the included CD-ROM.



Perennial pastures

Successfully established and managed perennial pastures including lucerne, veldt grass and evening primrose can increase productivity and reduce groundwater recharge. But what increase in productivity is required for the investment to be viable?

Let's use the same **40ha block on class VII land** that was considered for local native species, saltbush and a product block.

Success with lucerne includes a development budget for dryland lucerne indicating that breakeven occurs three years after the establishment year when based on achieving a productivity of 5 DSEs/ha at approximately $38/DSE from the first year after establishment (3DSEs/ha in the year of establishment). The preparation and establishment costs are assumed to be approximately $185/ha.

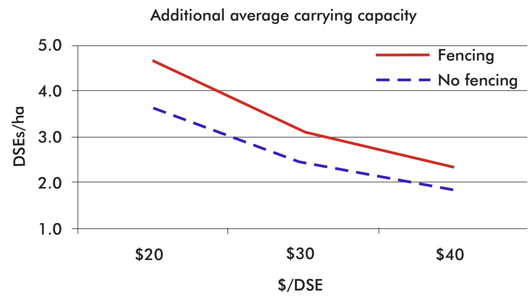
Adopting the same simplistic approach used in the other analyses, let's look at what increase in productivity is required to offset the additional costs:

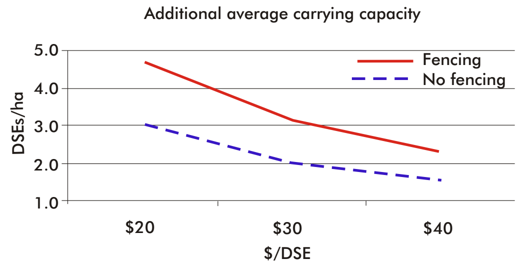
- Establishment $7400 (40ha @ $185/ha)
- $7200 for fertilising, pest control and weed control costs averaging $45/ha from Yrs 2-5
- The same fencing cost of $4000 borne by the other enterprise options for this block to bring total costs of $18,600, however since fencing costs would normally be amortised over a longer period, the analysis compares the results with the fencing cost excluded

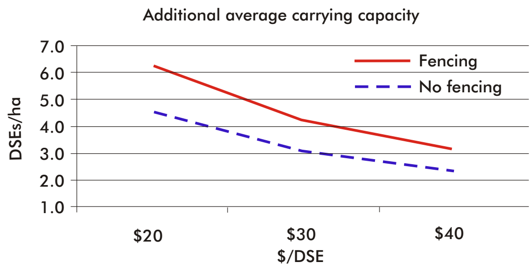
Based on $20/DSE, $30/DSE and $40/DSE respectively, the pre-pasture improvement carrying capacity would need to increase by a five-year *average** of 4.7, 3.1 and 2.3 DSEs/ha - regardless of what the prior carrying capacity might be.

Should fencing not be required a smaller increase is required as graphically illustrated.

*compensating for the light grazing in the first growing season







On the other hand if lucerne only persisted for three years, the average increase in productivity would need to increase by 0.5 DSEs/ha to 1.7 DSEs/ha depending on the GM and need for fencing.

If veldt grass and primrose cost two thirds of lucerne to establish and manage, but only persisted for three years (normally persists for 6-8 years if well managed), the increase in productivity required to offset the costs would be not as high.

A good decision about whether or not to establish perennial pastures should rely on the farmer's assessment of the prospects for increasing the carrying capacity significantly higher than the indicative breakeven point* - for the applicable GM ($/DSE) and other circumstances such as fencing. The increase is closely related to how long the pasture is expected to persist.

* to account for risk and the time delay until the investment is recouped

Further reading

Bulman PA, Beale P and Knight A 1998 *Growing broombush for profit and land protection* Primary Industries and Resources, SA, Bulletin 1/98 ISBN 0 7308 4314 9 - outlines most aspects of establishing, managing and harvesting broombush as well as identifying the key factors affecting profitability (24p colour A4); available from PIRSA and State Flora

Bulman P 2002 *The feasibility of attracting significant private investment into forestry in the* Adelaide *Hills and Fleurieu Peninsula* Mount Lofty Ranges Farm Forestry Group - compares different opportunities for off-farm investment into primary production; see *Feasibility of forestry investment.pdf* on included CD-ROM

Bulman PA and Geddes DJ 2003 *Comparitive economic analyses of forestry and agriculture in the north west region of Victoria Forestry as agriculture* Department of Natural Resources and Environment, Victoria - provides an evaluation of farm forestry opportunities in the Victorian mallee and Wimmera; see *Forestry as agriculture NW region Vic.pdf* on the included CD-ROM

Bulman PA 2003 *Shelter systems what are they worth?* Special Liftout, Australian Forest Grower, Vol. 26, No. 4 - synthesizes the overseas and comprehensive recent Australian research on crop shelter responses, outlines how to design for purpose and the challenge of coming up with a cost-effective design for a Wimmera case study (8p); see *Shelter systems.pdf* on included CD-ROM.

Krause M 2000 *Preliminary financial assessment of* '*Cell Grazing*' *of saltbush on Peter, Kerry and Brenton Kroehn*'*s property at Waikerie* is a study undertaken by Applied Economic Analysis Pty Ltd for the River Murray Catchment Water Board - shows break-even carrying capacities and sensitivities based on discounted cash flows; copy resides with MMLAP, Murray Bridge

Poynter M & Borschmann R 2002 *An investigation of the commercial viability of producing plantation-grown eucalypt firewood in the Mount Lofty Ranges* Mt Lofty Ranges Farm Forestry Group - a feasibility study on growing firewood in higher rainfall areas nearer to the Adelaide market; see *Viability of firewood.pdf* on included CD-ROM

Proceedings from the *Low Rainfall National Farm Forestry Conference* 2002, Longerenong College, University of Melbourne - an interesting array of papers that include valuable data on hardwood yields; try Horsham Office of Victorian Department of Sustainability and Environment

Reid R 1999 *Review of farm forestry and extension potential at the Bridgewater alley farming site* A report for Low Rainfall Alley Farming Project, Primary Industries and Resources SA, Department of Natural Resources and Environment funded by Murray Darling Basin Commission - provides a simple and compelling insight into the value of wood products required to warrant using trees in alley farming systems; on the enclosed CD-ROM as *Bridgewater alley farming report Reid.doc*

Rural Industries Research and Development Corporation 2000 *Emerging products and services from low rainfall farm forestry* Joint Venture Agroforestry Program, RIRDC Publication 00/171 - provides an overview of the quest to find economically viable wood-based industries in the sheep-wheat belt of southern Australia; download from www.rirdc.gov.au

Stanley M, Britton R & Christinat R 2002 *Success with lucerne* PIRSA should be available from PIRSA/Rural Solutions, SA outlets

Sudmeyer R 2002 *Tree root morphology in alley systems* Joint Venture Agroforestry Program, RIRDC Publication No 02/024 - provides an understanding of the importance of root competition control and the inherent constraints of ripping on deep sands; download from www.rirdc.gov.au

Warren B and Casson T 1997 *Saltbush provides limited feed value* Farming Ahead 64, 67 - background information on trials investigating saltbush feed value

Warren B 1996 *Saltbushes for forage-where have we been and where are we going* Australian Journal of Soil and Water Conservation 9, 4144 - also interesting background reading on the role of saltbush in Murray Mallee farming systems

Williams OB (undated) *Atriplex nummularia (Lindl.) Oldman saltbush* Review and bibliography, unpublished paper - a good starting point for those wanting to know what has been written on saltbush

Williams OB 1963 *The response of Oldman saltbush to nitrogen and phosphorous* Field station record, 2, 7982
some background reading regarding the apparent common need to fertilise to achieve and maintain satisfactory production levels

Yeatman T (Ed.) 2004 *Farm Gross Margin Guide A gross margin template for crop and livestock enterprises* Rural Solutions, SA - provides a cost base to compare with prospective returns based on yield and price for different enterprise options in different rainfall zones; available from PIRSA for $11

Soil conservation

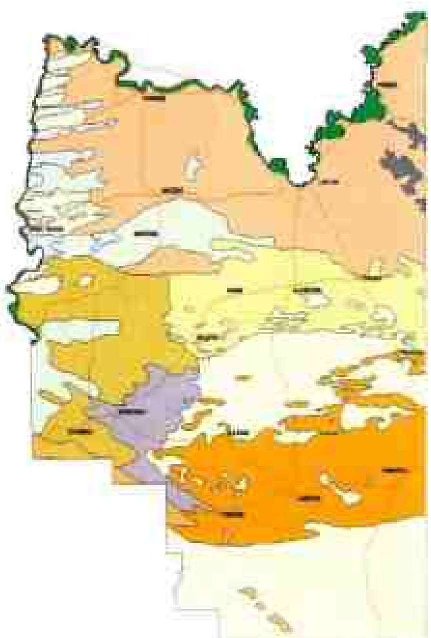
District Soil Plans describe what to do about land management issues (wind erosion, organic matter decline, rabbits, native vegetation decline, salinity, water repellence and boron toxicity). The plans incorporate the fundamentals of land capability mapping and property management planning and the following summaries may be a helpful toolkit in relation to wind erosion. The District Soil Plan for the Murray Mallee is included on the CD-ROM as *MM Soil Con Board District Plan.pdf*. You can also visit www.soil.pir.sa.gov.au/html/nav_dist.htm.

Key land capability classes

The table below briefly summarises the key land capability classes; a more comprehensive outline can be found on page 37 of the *District Soil Plan*.

II	Most productive cropping flats with mainly loamy soils, stony rises and limestone plains and sinkholes land with low to moderate potential for wind erosion
III	Sand spreads and loamy sands on flats and gently undulating small rises land with moderate potential for wind erosion
IV	Semi-arable low sandhills and periodically croppable with stubble retention, minimum tillage and improvements to soil fertility land with moderate to high potential for wind erosion
V & VI	Not applicable in the Murray Mallee (referring to non-arable land with steep slopes and
VII	Non-arable mainly steep jumbled coarse-textured sand dunes with little organic matter land with very high potential for wind erosion

Those attending property management planning courses use a 'rainbow' chart to work out the limiting factors, hence land capability class. Contact the Soil Conservation Board through PIRSA to obtain a copy if required.



Land units map

See *MM Soil Con Board District Plan.pdf* on the CD-ROM for more information on the land units

Assessing ground cover

Groundcovers, stones and clods reduce wind erosion.

About 50% prostrate plant cover (with 30% anchored) is needed to minimise wind erosion on sandy soils. For standing stubble, the minimum cover needed for any protective effect is 30%.

PIRSA Fact Sheet No: 8/2001 *Field method for measuring soil surface cover* describes the 'wire method' and is available from www.pir.sa.gov.au/factsheets and on the included CD-ROM as *Assessing soil cover.pdf*.

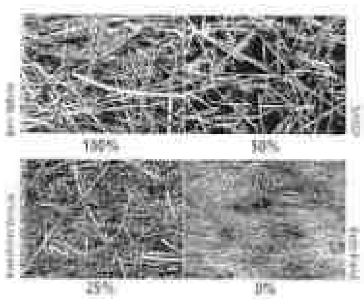


Photo standards taken in plan view are used to estimate the percentage of plant cover (Farmnote No. 40/90 *The amount of stubble needed to reduce wind erosion* Agdex 571 is meant to provide these photo standards, but this sheet does not seem to be accessible from the web.) The photo on the right was sourced from *Stubble and minimum tillage stop soil (erosion)* SARDI & Kondinin and is available on the included CD-ROM as *Sustain_landmanage_stopsoil.pdf*

Stabilising sand drift

Murray Mallee and Murray Plains Soil Conservation Board Fact Sheet *Stopping the sand drift* for control along fence lines:

- Sow a minimum 50m strip along fence lines with rye at 60 kg/ha or triticale at 80 kg/ha as soon as there is sufficient moisture after end of March
- Northern Mallee - at least 7 kg/ha of N and 10 kg/ha of P eg 70 kg/ha of MAP; Southern Mallee and Murray Plains areas -10 kg/ha of N and 10 kg/ha of P eg 55 kg/ha of DAP
- Avoid cultivating bare areas
- Resow areas damaged by the wind after sowing as soon as possible
- Consider feedlotting stock to protect paddocks with limited surface cover

Coorong and Districts Soil Conservation Board Fact Sheet *Wind erosion control* for treatment of old blowouts, areas around vegetation and shallow sweeping erosion:

- Old blowouts - spread old hay or straw letting stock, preferably cattle walk it into the blowout
- Areas perennially drifting around vegetation - avoid cultivation closer than 10m; deep rip the roots; control rabbits; and establish permanent pastures in this zone (if rainfall is adequate)
- Shallow sweeping erosion - avoid cultivation, retain stubbles and spray to fallow; avoid cultivating and seeding susceptible areas after a late break or poor rainfall; roll wind-blasted crops with a cross-angle iron stone roller to leave ridges at right angles to the damaging winds

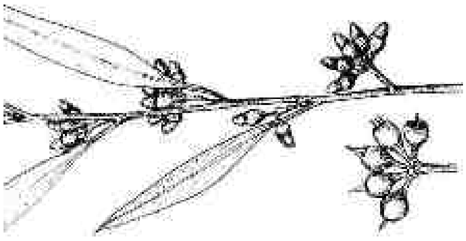
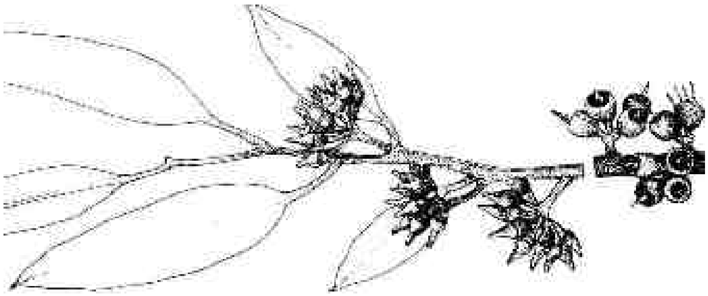
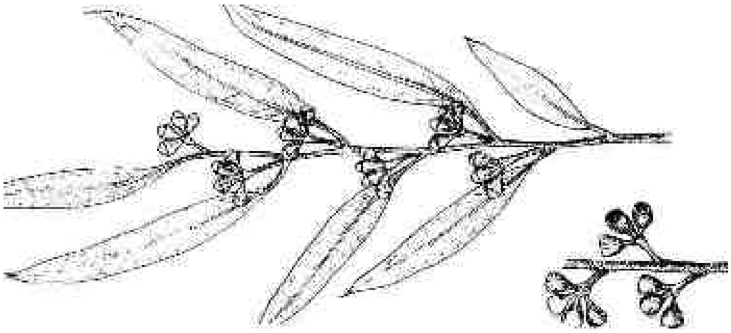
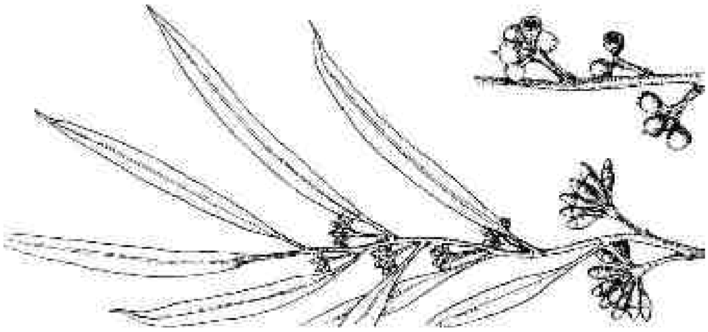
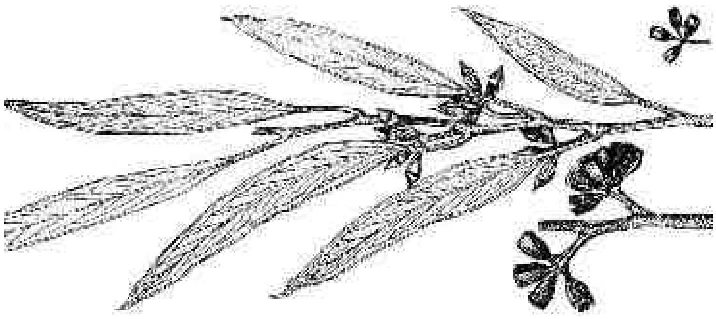
Soil texture testing

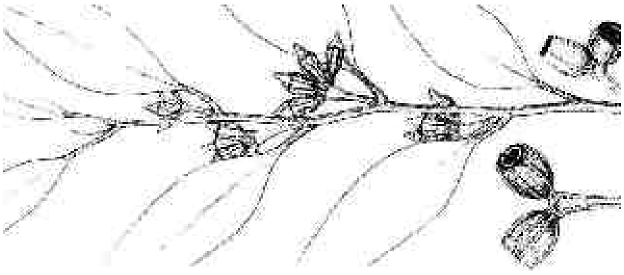
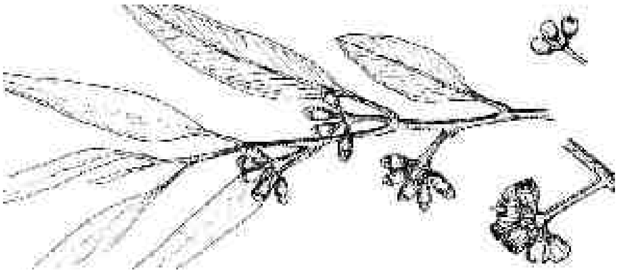
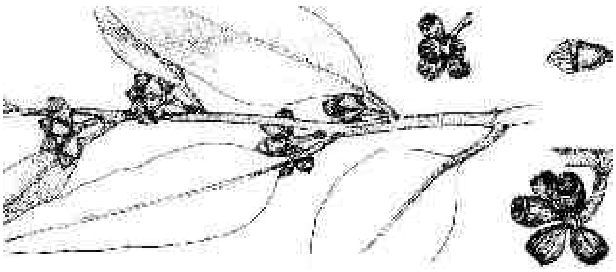
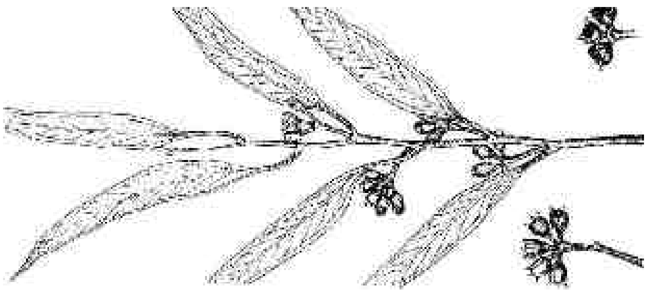
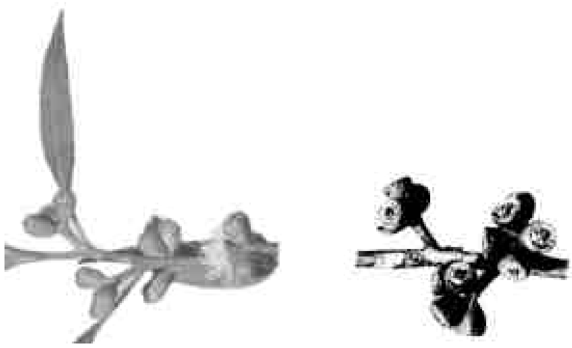
(from Nash, D 1998 *What is soil?* Agriculture Notes, Natural Resources and Environment, Victoria AG0058 ISSN 1329-8062)

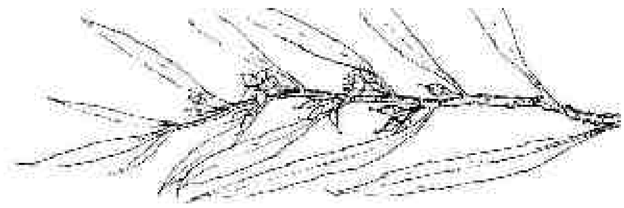
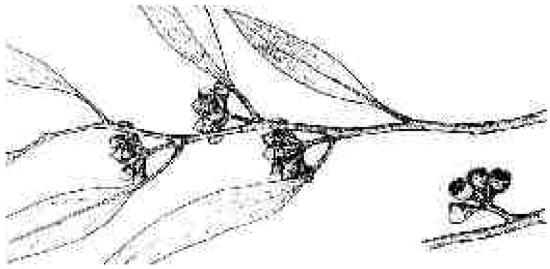
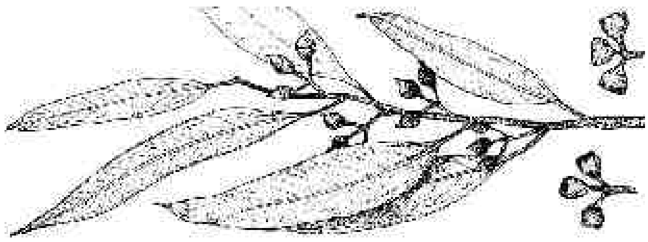
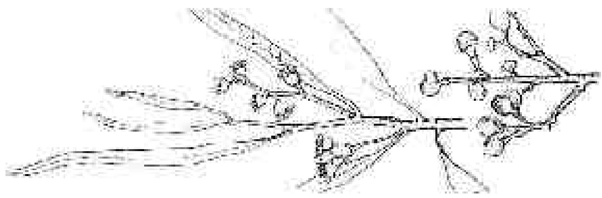
Sand	Loose gritty feel and does not stick together. Individual sand grains can be seen or felt.
Loamy sand	Particles barely stick together and a moulded piece of soil just holds its shape.
Sandy loam	Sticks together more than a loamy sand but can be easily broken. Individual sand grains can be felt and heard if a wet sample is rubbed between the index finger and thumb and held close to the ear.
***Silty loam**	Like a loam but has a smooth silky feel when a moist sample is pushed between the index finger and thumb. On drying a sample can form a hard lump but this may be broken by hand.
Loam	Breaks into crumbs but will tend to stick together. Sand grains cannot be felt in a moist sample which when squeezed will retain its shape when handled freely. Loams are usually soft to the feel.
Sandy clay loam	Like a clay loam but sand grains can be felt (and heard - see Sandy Loam)
***Silty clay loam**	Like a clay loam but silty as well and smooth to the touch.?
Clay loam	More easily moulded into a shape than a loam, a clay loam rolls out to a thin ribbon between the palms while a loam will break-up. When dry a clay loam will form a lump but is not as tough to break as a clay.
Sandy clay	Like a clay but sand grains can be felt (and heard - see Sandy Loam).
***Silty clay**	Like a clay but smoother.
Clay	Tough and can be moulded into shapes when moist. Clays form a long flexible ribbon when rubbed between the palms and the ribbon can often be bent into a "U" shape without breaking. Clays dry into very hard clods.

* These texture classes are not noted in the Murray Mallee. The *Soil description handbook* by Ken Wetherby or *Better soils* field texture guides include the light sandy clay loam which is common on calcareous soils.

Identifying key dominant tree species *(after Nicolle 1997 and Boomsma 1981)*

Species, soils and flowering	Buds, fruits and leaves (approx 0.5 times actual size)
Red mallee *Eucalyptus oleosa* Soils variable Most frequent in winter-spring	
Red mallee *Eucalyptus socialis* Sands to heavy loams Summer	
Yorrell *Eucalyptus gracilis* Deep red sands to clay-loams Autumn-winter	
Slender-leaved mallee *Eucalyptus leptophylla* Sandy soils on plains Summer-autumn	
Square-fruited mallee *Eucalyptus calycogona* Heavy soils or low well-drained areas Winter-spring	

Species, soils and flowering	Buds, fruits and leaves (approx 0.5 times actual size)
Yellow mallee *Eucalyptus incrassata* Low sandy ridges Autumn-late winter, spring or summer pending district	
White mallee *Eucalyptus dumosa* Loams over limestone Late winter-summer	
Blue-leaved mallee *Eucalyptus cyanophylla* Sands Winter-spring	
Gilja *Eucalyptus brachycalyx* Plains soils Summer-autumn	
White mallee *Eucalyptus phenax syn anceps* Sands, loams and light clays Flowering time not noted in Nicolle	

Species, soils and flowering	Buds, fruits and leaves (approx 0.5 times actual size)
Sugarwood *Myoporum platycarpum* Shallow loams over limestone flats August-September	
Mallee box *Eucalyptus porosa* Low lying areas and undulating plains with sands or loams in less southern areas Summer	
SA blue gum *Eucalyptus leucoxlyon* Dune swales and undulating plains on sands to sandy loams without calcrete in less arid southern areas Autumn-spring	
Bullock bush Alectryon *oleifolium* Plains with clay loams to loams with broken calcrete December-March	

Murray Mallee sub-regions
N = north of Alawoona
C = extends down to include the cropping country just south of Lameroo-Pinaroo

Species list

Many of the mid- and understorey species occur in most of the vegetation communities. So to compile your species list for a project you can:

- Either identify the soil type and sub-region then select your species from the table below (or as *Species.xls* on the CD-ROM) that shows the range of suitability for each species.
  DS - can be direct seeded or easily propagated as seedlings
  S - seed difficult to collect so best to propagate as container-grown seedlings
  V - likely to volunteer on many sites, but could be grown as seedlings or possibly direct seeded if seed is absent
  C - difficult to propagate from seed and normally propagated by taking and striking cuttings in a nursery
- Or determine the vegetation community using the *Pre-European settlement vegetation* map (in a plastic sleeve), soil type and dominant species in the nearest remnant native vegetation on comparable soils, then work from the lists provided in data base and fact sheets from the *Native vegetation of the Murray Region of South Australia* CD-ROM (contact Murray Mallee LAP, ph 08 8531 2066 or email mmlap@lm.net.au to borrow a copy) for that community.

Species	Propagation	Deep sand			Sand spreads & loamy sands			Loams & clays			Shallow loam			Notes
Acacia argyrophylla	DS					C			C			C		Restricted to Murray Plains
Acacia brachybotrya	DS	?	?	?	N	C	S	N	C	S	N	C	S	Closely related to A argyrophylla
Acacia calamifolia	DS		C			C								Acacias require hot water treatment
Acacia ligulata	DS	N	C		N	C		N	C		?	?	?	Hot water treatment
Acacia lineata	DS	?	?	?		C			C		?	?	?	Hot water treatment
Acacia montana	DS	?	?	?		C			C		?	?	?	E side of central zone with native pine
Acacia myrtifolia	DS			S										Hot water treatment
Acacia nyssophylla	DS							N			N			Hot water treatment
Acacia oswaldii	DS	N	C		N	C		N	C			C		Hot water treatment
Acacia pycnantha	DS					C	S		C	S		C	S	Hot water treatment
Acacia rigens	S	N	C		N	C		N	C					Often difficult to collect sufficient seed
Acacia sclerophylla	DS				N	C		N	C		N	C		Hot water treatment
Acacia spinescens	DS		C	S		C	S		C	S		C	S	Hot water treatment
Acacia wilhelmiana	DS	N	C		N	C		N	C					Hot water treatment
Alectryon oleifolius	S	N			N			N	C	S	N	C	S	
Allocasuarina luehmannii	S						S			S				Seed rarely plentiful
Allocasuarina muelleriana	DS			S									S	Similar to A pusilla
Allocasuarina pusilla	DS			S										SE mallee on infertile sands
Allocasuarina verticillata	DS												S	Only E side of central mallee
Astroloma conostephiodes	S		C	S		C	S		C	S		C	S	See What seed is that?
Atriplex pumilio	V				N			N						If seed is used, it needs leaching
Atriplex semibaccata	V													Maybe restricted to the floodplain
Atriplex stipitata	V				N			N			N			If seed is used, it needs leaching

Species	Propagation	Deep sand	Sand spreads & loamy sands	Loams & clays	Shallow loam	Notes
Atriplex vesicaria	V		N C S	N	N	If seed is used, it needs leaching
Banksia marginata	S		S	S		
Banksia ornata	S		S			Use infertile medium
Beyeria lechenaultii	S	S	N C	N C	C	
Billardiera cymosa	S	S	C S			May require fresh seed and detergent
Boronia coreulescens	C	C S	S			Seed can be also be used on sand
Bursaria spinosa	S	S	C S	C S	C S	Requires fresh seed
Callitris canescens	S				C S	Mainly limestone-based soils
Callitris glaucophylla	S			N		Cold stratification for Callitris sp
Callitris gracilis syn preissi	S	N C S	N C S	N C S	N C S	Cold stratification for Callitris sp
Callitris verrucosa	S	N C S	N C S	N C S	? ? ?	Particularly on the S side of dunes
Calytrix tetragona	S		C S	C S	C S	Sow seed with attachment
Carpobrotus rossii/modestus	V	N C S	N C S	N C S	N C S	
Cassytha melantha	?	N C S	N C S	N C S	N C S	
Casuarina pauper	S	N	N			
Chenopodium desertorum	V		N C S		N C S	
Clematis microphylla	DS	N C S	N C S	N C S	N C S	Difficulty sometimes experienced
Correa schechtendalii	C	C S	C S			Can also be grown from seed
Danthonia sp	V		N C S	N C S	C S	May require fresh seed
Dianella revoluta	S	N C S	N C S	N C S	N C S	Can be direct seeded & can volunteer
Dillwynia hispida	S	S	S			Hot water treatment
Dodonaea hexandra	DS			S	S	Limestone, rapid hot water treatment
Dodonaea viscosa var angustissima	DS	N C	N C	N C	N C	Benefit from rapid hot water treatment
Dodonaea viscosa var spatulata	DS	C S	C S	C S	C S	Benefit from rapid hot water treatment
Einadia nutans	V	N C S	N C S	N C S	S	
Enchylaena tomentosa	V	N C S	N C S	N C S	N C S	
Eremophila glabra	S		N C	N C	N?	Cuttings, see What seed is that?
Eremophila longifolia	S		N C	N C	N C	Cuttings, see What seed is that?
Eriochiton sclerolaenoides	?		N C S	N	N	Hard to propagate
Eucalyptus arenacea	DS	S	C	C		Only E side of southern mallee
Eucalyptus brachycalyx	DS		N C S	N C S	N C	Only E side of mallee
Eucalyptus calycogona	DS		N	N	C S	
Eucalyptus cyanophylla	DS	N	N S	S		
Eucalyptus diversifolia	DS	S	C	C	S	Coastal; limestone
Eucalyptus dumosa	DS	N C	N S	N S	N C	
Eucalyptus fasciculosa	DS	S		C	S	Poorer soils
Eucalyptus gracilis	DS		C S	N S	N C	Occurs on E side of southern mallee
Eucalyptus incrassata	DS	C S	C S	C S	S	Some occurrence in northern mallee
Eucalyptus leptophylla	DS	N C S	N C	N C	C	
Eucalyptus odorata	DS		C	C	C	Viability can be low from inbreeding
Eucalyptus oleosa	DS		N C S	N C S	N C	
Eucalyptus phenax syn anceps	DS	N C S	N C	N C	N C S	
Eucalyptus porosa	DS		C S	C S	C	
Eucalyptus socialis	DS	N C S	N C S	N	N C S	Usually over limestone
Exocarpos aphyllus	S	N C	N C S	C S	N	Also E side of S zone, difficult
Exocarpos sparteus	S	N C S	N C S	N C S		Absent from W of N zone, difficult
Gahnia lanigera & deusta	V				C S	
Geijera linearifolia	S				N C	Seed needs washing and to be fresh

Species	Propagation	Deep sand			Sand spreads & loamy sands			Loams & clays			Shallow loam			Notes
Grevillea hueglii	S				N			N						Difficult to collect; What seed is that?
Grevillea ilicifolia	S		C	S		C	S		C	S				Difficult to collect; What seed is that?
Grevillea lavandulaceae	S			S			S							Difficult to collect; What seed is that?
Hakea muelleriana	S			S			S			S				Slow to collect
Halgania andromedifolia	S	?	?	?	N			N			?	?	?	
Helichrysum spp	V									S			S	
Hibbertia riparia	C		C	S		C	S							Seed difficult to germinate
Hyalosperma semisterile	?				N	C	S	N			N			
Kennedia prostrata	S			S			S							Hot water treatment
Kunzea pomifera	C			S			S							Can also grow seedlings
Lasiopetalum behrii	C									S			S	Over limestone; seed difficult to collect
Lavetera plebeia	?	N	C	S	N	C	S	N	C	S				Usually along water courses, river flats
Lawrencia squamata	?													
Lepidosperma carphoides	C			S			S							Sandy heath communities
Lepidosperma sp	C	N	C		N	C	S		C	S		C	S	Fresh seed OK for seedlings
Leptospermum coriaceum	S		C	S		C	S							Might also be direct seeded
Lomandra effusa	C				N	C	S	N	C	S	N	C	S	Can also use fresh seed
Lomandra sp	C	?	?	?	N	C	S	N	C	S	N	C	S	Can also use fresh seed
Maireana brevifolia	V				N	C		N	C		N	C		
Maireana erioclada	V				N			N			N			
Maireana pentatropis	V				N			N						
Maireana pyramidata	V							N			N			Tolerates slightly saline soils
Maireana rohrlachii	V							N	C		N	C		
Maireana sedifolia	V				?	?	?	?	?	?	N			Shallow limestone soils
Melaleuca acuminata	DS					C	S		C	S				
Melaleuca brevifolia	DS						S			S				Saline soils, riparian
Melaleuca lanceolata	DS			S	N	C	S	N	C	S		C	S	
Melaleuca uncinata	DS		C			C	S		C	S			S	From dune rises to saline flats in S
Minuria leptophylla	S				N	C	S	N	C	S				See What seed is that?
Myoporum montanum	C										N			W part of N mallee and floodplain
Myoporum platycarpum	C	N	C		N	C		N	C		N	C		See What seed is that? for seed
Olearia pimeleoides	S				N			N			N			Difficult - may require fresh seed
Phebalium bullatum	?	N			N									Rare
Pittosporum phylliraeoides	S					C		N	C	S	N	C	S	Wash in detergent
Prostranthera aspalathoides	C							N	C		N	C		Difficult to collect; cuttings reliable
Rhagodia candolleana	V			S			S							Coastal soils and common understorey
Rhagodia parabolica	V	N			N			N			N		S	
Rhagodia sp	V					C	S		C	S		C	S	As described in the Biological survey
Rhagodia spinescens	V				N			N	C	S	N	C	?	
Santalum acuminatum, apiculatum & murrayanum	S	N	C		N	C		N	C		?	?		Difficult - needs fresh seed and host
Scaevola spinenscens	S				N	C		N	C				S	May take long time to germinate
Sclerolaena sp	V	N	C	S	N	C	S	N	C	S	N	C	S	
Senecio sp	V	N	C	S	N	C	S	N	C	S	N	C	S	
Senna artemesioides var petiolaris	DS	N			N	C	S	N	C	S	N	C	S	Also var coriacea or filifolia
Stipa sp	V	N	C	S	N	C	S	N	C	S	N	C	?	Difficult - may require fresh seed
Themeda triandra	S			S			S			S	?	?		Uneven maturation of seed
Triodia scariosa	V	N	C		N	C								Includes dormant seed, hard to collect
Vittadinia sp	V	N	C	S	N	C	S	N	C	S				
Westringia rigida	V	?	?	?	?	?	?	?	?	?	N			Cuttings and seed - What seed it that?
Xanthorrhoea caespitosa	S			S			S							May also be able to be direct seeded
Zygophyllum apiculatum	V	?	?	?	N			N			N			Other species as well; grow seedlings

Recommendations

The following recommendations regarding implementation and further research (local and national) are largely based on the inferences from the *Analysis of options* and *Establishment* sections and are for MMLAP consideration:

1. Holding **workshops and field days** for facilitators, INRM board members, advisers, consultants and interested farmers based on these *Guidelines* is likely to constitute significant step towards improving the quality of private and public decision making regarding investment in the use of perennial vegetation in the Murray Mallee.
2. The number of sets of the ***Guidelines*** printed is likely to be limited due to demand and associated cost, however wider **distribution** could be achieved via the **MMLAP website and CD-ROM production** - but promoted by the preparation and distribution of a **4-6 page overview brochure**.
3. Improving the understanding of the **carrying capacity and supplementary feeding costs of alternate saltbush** systems (designs) seems pivotal to improving the understanding about where and when saltbush does and doesn't have a role in improving the viability of Murray Mallee farming systems.
4. Demonstrating and quantifying the **production responses and health of saltbush to application of different rates of different sorts of fertiliser on different soil types** will clarify our understanding of the scope for saltbush in Murray Mallee farming systems - especially for inherently infertile deep sandy soils.
5. Prior to establishing extensive areas **saltbush on shallow stony sites**, it is important to assess the likelihood of saltbush roots being able to find cracks in the calcrete (page 22); mounding soils along the planting lines of shallow stony sites should increase the soil volume and enable saltbush roots to more effectively find cracks in the calcrete.
6. **Targeting revegetation with local native species** for agricultural shelter and 'general biodiversity benefits' **on all roadsides** (subject to road safety design and other considerations) **and other public land** in the Murray Mallee provides a far superior 'return on investment' than most in-paddock shelter systems and biodiversity conservation revegetation projects - in contrast to relying on farmers to forego agricultural production in perpetuity.
   It is noted however that such an extensive network of roadside vegetation may not necessarily improve the conservation status of uncommon, rare and endangered species but it should markedly improve the linkage of currently very fragmented remnant native vegetation.
7. **Acquiring properties to revegetate in a bid to improve connectivity in high priority fragmented landscapes** seems to be a more equitable, cost-effective and strategic approach to biodiversity conservation than just fostering naturally occurring farmer interest - regardless of the location and strategic importance.

This does not however infer that such investment should necessarily be in lieu of protecting remnant native vegetation or fostering sensible projects with farmers who are already interested.
There seems to be a strong need to develop a clear rationale for biodiversity conservation investments - on the basis of evaluating the relative cost-effectiveness of different options for improving the conservation status of species. This might involve an objective assessment of different conservation project or program options in terms of cost and expected impact, that is the number of species that might be changed from uncommon to common or rare to uncommon et cetera.

8. Standard practice for **revegetation projects** using direct seeding and/or planting of local native species should include a **site assessment** that incorporates: checking for hard-to-kill perennial weeds (ideally in the year prior); checking for sodicity and salinity; checking for the occurrence of compacted hard setting soils; checking for insect predation; assessing the moisture holding capacity of the soil profile and an assessment of the actual soil moisture reserves before and after seeding.
9. Improving the understanding of the **carrying capacity of perennial pastures** seems pivotal to improving the understanding about where and when lucerne/veldt/primrose do and do not have a role in improving the viability of Murray Mallee farming systems.
10. **Investigating and demonstrating the potential for establishment and persistence of lucerne** in the northern Murray Mallee on deep soil profiles with storage of at least 250mm of water is an essential precursor to wider adoption.
11. Blocks of **firewood and/or broombush** warrant consideration as an 'insurance policy' to buffer on-farm incomes in drought years.
12. **Subsiding the cost of establishment of perennial vegetation** options that personally suit individual farmers seems logical for reducing rates of groundwater recharge along the river 'corridor' and for permanently stabilising capability class VII land throughout the remainder of the Murray Mallee.
13. It seems worthwhile to **influence research priorities for key organisations** by advising them of the issues largely identified in the *Analysis of options* and *Establishment* sections and including:
    - Improving the understanding of the factors limiting the success of direct seeding on coarse sandy soils - incorporating nutrition and moisture retention on early root radicle development in a bid to develop ameliorative treatments such as spot site treatments and nutrition in different formulations including seed pelleting. Agroforestry Australia (formerly the Joint Venture Agroforestry Program - Rosemary Lott in Canberra), Greening Australia (David Carr in Canberra office) and DAWA (John Bartle in Perth)
    - Evaluating suitability and productivity of *Medicago arborea* - subject to making enquiries about existing Australian initiatives (relevant CRCs)