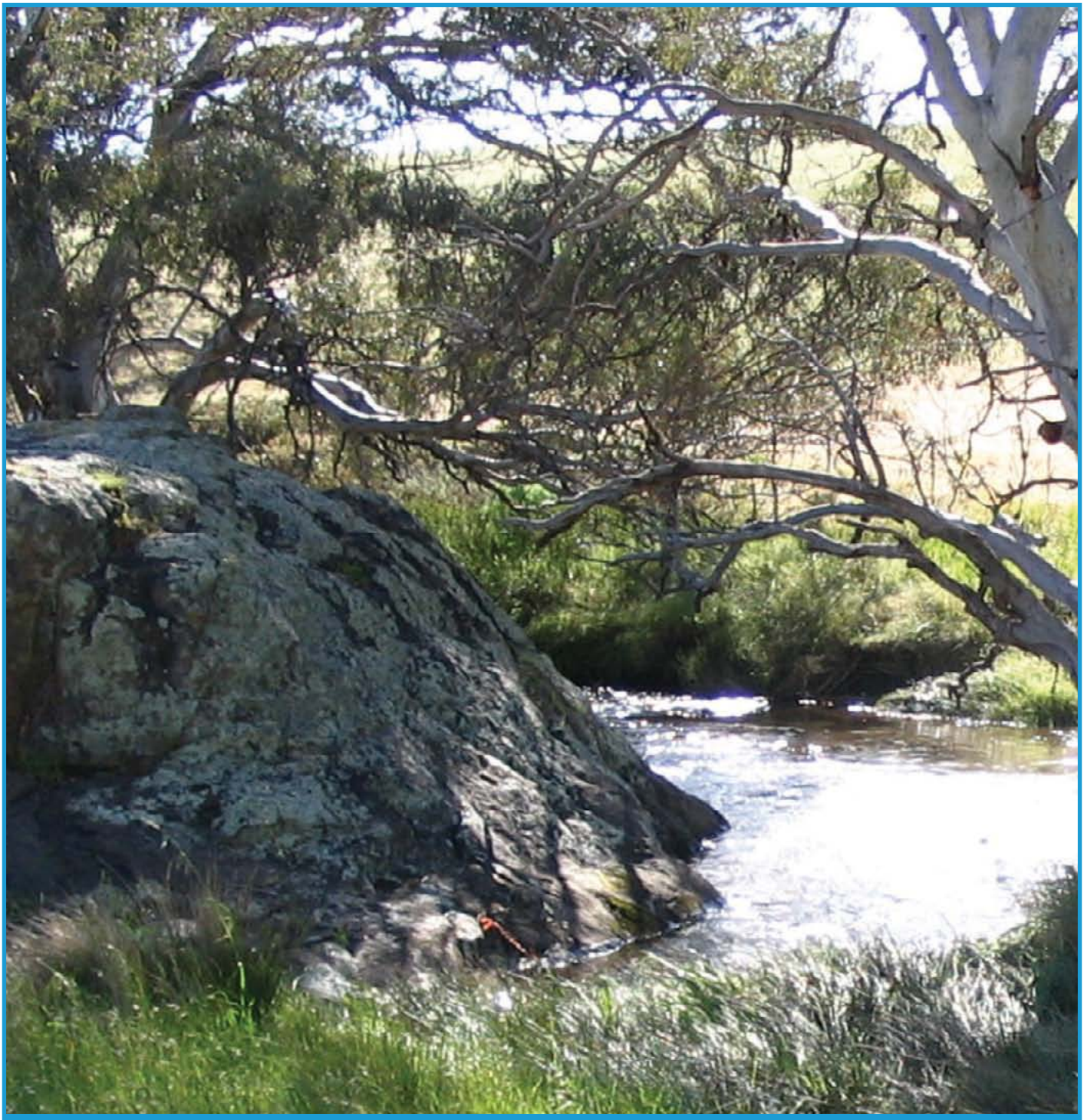
Watercourse Restoration Guideline

for the Goolwa-Wellington LAP Region

GOOLWA TO WELLINGTON LOCAL
ACTION PLANNING ASSOCIATION INC

Australian Government

Government of South Australia
South Australian Murray-Darling Basin
Natural Resources Management Board



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- Mercer, K. (2006) *Corridors & Buffers for the Goolwa-Wellington LAP Region*, Goolwa to Wellington Local Action Planning Board.
- *Managing your watercourse: A guide for watercourses in the Goolwa to Wellington and Eastern Hills and Murray Plaings LAP Regions* (anonymous fact sheet)
- Miles, C. (2007) *Meadows Creek Rehabilitation Plan Part 2: Watercourse Restoration Methods*, 2nd Draft, Prepared for the District Council of Mt Barker, Rural Solutions SA.

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1 Introduction

1.1 Aim

This fact sheet is intended as a guide to assist in managing, restoring, revegetating and maintaining watercourses on your property. It uses broad catchment zones to suggest appropriate species foreach zone.

For assistance regarding specific species appropriate to your property, please speak with your Local Action Planning (LAP) officer.

1.2 Catchment Region And Planting Zones

The catchment areas for the Goolwa-Wellington LAP cover a large area, from Port Elliott and Hindmarsh Island in the south to Meadows, Kanmantoo and Harrogate further north. It incorporates the Alexandrina Council area, and parts of the Mt Barker, Murray Bridge and Barossa Councils. Over such a large area there are a variety of possible site conditions. To help with suitable species selection, broad zones have been used to assist with species selection, however these zones should be considered a guide only and landholders should seek advice from LAP project officers or revegetation consultants to develop species lists specific to their property.

1.2.1 Northern High Rainfall

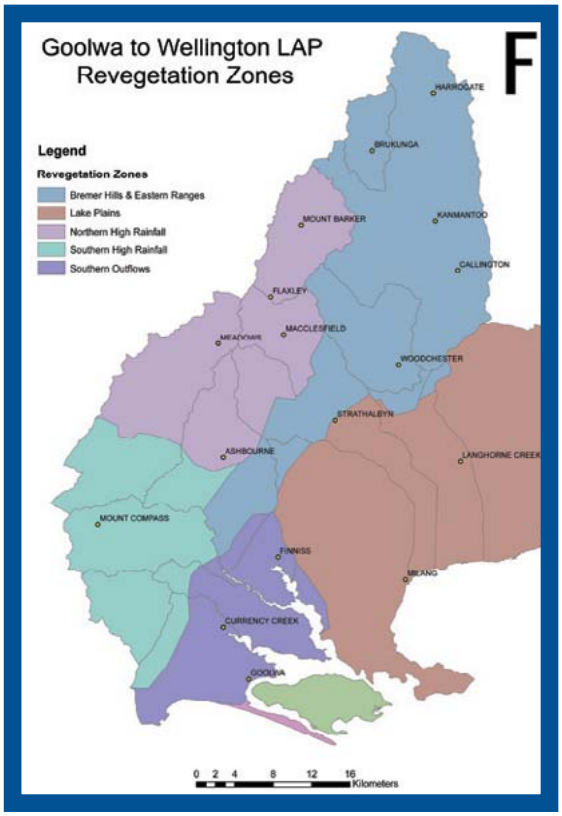
This area includes the upper catchments of the Mt Barker Creek, Angas River and Finniss River and the towns of Mt Barker, Flaxley, Meadows, Macclesfield and Ashbourne as well as the Kuitpo area. Average annual rainfall is greater than 700mm. The major watercourses are situated in moderately sloping valleys. The watercourse vegetation consists of River Red Gums over Silver Banksias, Woolly and Prickly Tea-trees and wattles, over sedges, rushes and grasses.

1.2.2 Southern High Rainfall

The area includes the upper Tookayerta and Currency Creek catchments, the town of Mt Compass and the Yundi, Nangkita, Tooperang and Cleland Gully areas. The average annual rainfall is above 700mm. The catchment soils are more sandy than the "Northern High Rainfall" area and the watercourses contain numerous swamps. Many watercourses hold water all year around. Most swamp areas are dominated by sedgelands and shrublands with low Eucalypt woodlands over heath on the perimeters and along non-swampy watercourses.

1.2.3 Bremer Hills & Eastern Ranges

This area includes the catchments of the middle and upper Bremer, Mt Barker Creek below Mt Barker Springs, Rodwell and Red, the middle Angas and Bull Creek. It includes the towns of Harrogate, Nairne,



Callington, Wistow and extends south-westwards uphill from Strathalbyn almost to Ashbourne. Average annual rainfall ranges between 400 and 700mm. The watercourses are mostly situated in moderately to steeply sloping valleys, dropping relatively steeply off the eastern Mt Lofty Ranges, and mostly flow seasonally with main channels holding permanent water. Saline water can be common. The vegetation is predominately River Red Gum woodlands over a layer of wattles, shrubs and hop bush over grasses, sedges and rushes. Sheaoks are often found growing on the rocky bank edges.

1.2.4 Southern Outflows

This area includes the Lower Finniss River, Tookayerta and Currency Creeks, and the localities of Finniss, Mosquito Hill and Currency Creek. Average annual rainfall is around 400mm to 700mm. The watercourses flow out from narrow valleys onto the plain, often with sandy deposits on the floodplains and rocky beds. There are also heavier clay soils in the surrounding areas where water can sit in shallow depressions. There are some large swamp sedgelands, otherwise the watercourse vegetation is dominated by River Red Gums over River Bottle-brush, wattles, native grasses, sedges and rushes.

1.2.5 Lake Plains

This area includes the lower Bremer and Angas Rivers and the towns of Strathalbyn, Langhorne Creek and Hartley. The watercourses are deeply cut into the loamy floodplains, flooding occasionally and receding to disconnected permanent pools in drier seasons. The depth of the channels results in the upper banks drying out considerably. The average annual rainfall is below 400mm. The vegetation is typically River Red Gum over sedges, rushes and grasses with an open middlestorey mainly consisting of Lignum bushes and various wattle species.

2 Managing Your Watercourses

Watercourses are a valuable resource for landholders, the wider community and the environment. Watercourses provide habitat for both aquatic and terrestrial (land-based) plants and animals. The water is used by people for stock, irrigation and domestic use.

The vegetation along most watercourses has been heavily modified, either through on-going grazing or active clearance. The shape and flow of many watercourses has been altered by dams, erosion, channel construction and water extraction, resulting in loss of and changes to habitats. Despite these impacts however, some watercourses are still in excellent condition, supporting rare ecosystems such as the critically endangered ecological community of Fleurieu Peninsula Swamps and fauna such as the Southern Pygmy Perch. However most watercourses are moderately to severely degraded and require active management to restore them.

2.1 Why Manage And Restore Watercourses?

Watercourses should be looked after and restored in order to:

- Improve water quality for humans and the environment
- Reduce erosion, loss of bank vegetation and siltation of pools
- Provide habitat for native fish, reptiles, birds and mammals
- Provide vegetated corridors between patches of remnant native vegetation
- Conserve and re-establish locally native plant species

- Improve the health of stock drinking the water and sheltering under vegetation
- Reduce weed infestations and the risk of weeds spreading
- Aesthetic value can increase land value
- Improve land management by subdividing paddocks
- Leave the property a better place

Adult native birds such as Ibis can eat 200 grams of pasture insects including crickets and beetle larvae a day. Multiply that by a flock of several thousand and estimates of half-a-million pasture grubs a day are realistic.

Native flora also helps encourage insects responsible for the pollination of plants, and dispersal of seeds and fruits.

3 Basic Principles

3.1 Fencing And Waterpoints To Control Stock Access

Stock that have unrestricted access to watercourses cause extensive damage including:

- Pugging soils
- Muddying and fouling the water
- Trampling, eating and preventing regeneration of native vegetation
- Baring the soil
- Damaging the banks
- Erosion

Fencing the watercourse is therefore the basic minimal requirement for restoring watercourses. In most situations, stock should be excluded entirely, however in some situations, short periods of controlled grazing may be useful. The main aim of such grazing would be to reduce the mass of perennial grassy weeds to:

- Enable re-growth to be sprayed, thereby ensuring less herbicide is used and is more effective
- Reduce fire fuel loads
- Make access easier to undertake other weed control activities such as woody weed control.

Sheep are better for such grazing than cattle as they tend to prefer the drier ground and as such, are less likely to cause negative impacts upon the water course.

3.1.1 Watering Points

Ideally, water should be supplied to stock in the paddocks adjacent to the watercourse via a reticulated watering system, with the trough located on high, hard ground. This will require the installation of a pump, header tank, pipes and trough

and, although an expensive up front cost, once installed, water can be reticulated throughout the property, allowing paddocks to be subdivided and rotational grazing implemented. Pumping from a watercourse or groundwater requires a licence from the South Australian Murray-Darling Basin Natural Resources Management (SAMDB NRM) Board.

Alternatively, stock access can be restricted to certain locations along the watercourse. This results in one area being heavily degraded whilst the protected areas are restored and therefore should only be used as a last resource. The watering area should be carefully chosen and may need to be re-enforced to reduce damage to aquatic flora and fauna and minimise the risk of erosion.

3.1.2 Crossings

Fencing the watercourse may also require that a crossing be installed. Crossings should be located on straight sections of watercourse with low, gently sloping banks. They should be carefully designed and constructed to take into consideration:

- How frequently the crossing will be used
- What type of vehicles or stock will be using it
- How much water flows along the watercourse during peak flood events.

Remember, a good crossing may be expensive but a poor crossing can cause a lot of damage, not only to your watercourse but potentially to your stock.

Constructing a crossing requires a permit from the SAMDB NRM Board.

3.2 How Wide Is Enough?

The distance of the fence from the top of the banks will depend on a number of factors including:

If the fence is being funded by a public grant – most funding programs have minimum requirements that must be met regarding riparian widths.

Whether the banks are eroding – the minimum distance of the fence from the top of an eroding bank should equal the height of the bank plus five metres.

The likelihood of flooding – fences are easily damaged by floods, therefore the fence should be situated above the flood level, or at least be positioned parallel to the direction of flow.

If the aim is to provide habitat for native birds and animals – then the wider the better, consider an overall width from one fence to the other of at least 30m.

How much time you have to manage the fenced-off area – the wider the fenced off area the bigger the area that requires management.

If the aim is to trap sediment run-off – a grassed buffer of at least 5m should trap most sediments, however, if at least 70% cover is maintained in paddocks at all times there should be minimal soil loss from paddocks.

Larger patches of revegetation support higher numbers and diversity of fauna depending on the nature of the vegetation type. Increasing the width of linear strips can avoid edge effects, encourage development of microclimates and support a greater number of wildlife.

3.3 Management of Riparian Remnants

Remnants should not be disturbed in the process of restoring a watercourse. A thorough **site assessment** should first be undertaken with someone who is skilled in plant identification. This allows for an understanding of the type of vegetation association(s) that may be present as well as which on-site factors need to be considered before planting, such as soil erosion, drainage issues, weed species, or limitations to planting such as overhead power lines or other services. Native vegetation can include native grasses, sedges, rushes and understorey plants like groundcovers and lilies, and it is important that these are not affected adversely by any planting.

Leptospermum lanigerum

4 Site preparation

4.1 Weed Control

To be successful with revegetation, you must control existing pasture and woody weeds well in advance of planting seedlings or direct seeding. Development of a weed management plan provides some structure for control, schedule for follow-up and monitoring of success. It should be developed in conjunction with a professional, particularly if chemicals are to be used.

The basic steps are:

Site assessment – *identify weeds; map weeds and features (including whether they are broadleaf, monocot, perennial and annual); understand why weeds are present; identify risks; identify any other flora and fauna (both onsite and adjacent – especially for riparian areas where legislation in relation to the use of chemicals within riparian zones may prescribe which chemicals can be used)*

Develop a plan – *determine priorities; set measurable objectives; plan for the longer term*

Implement strategy – *actions required to achieve objectives; actions to be time-lined and measurable; commence actions*

Monitor and review – *map weeds (note that new weed species can occur as the soil is disturbed or other weeds are removed); assess impacts of actions; determine what has worked and what hasn't; revise plan if objectives not being met (return to step 1)*

Phalaris aquatica

A perennial grass up to 1.6m tall, this is a significant watercourse weed and bush invader. It is widely used as a pasture grass.

If not grazed, the plant can reach its full height, becoming rank and overgrown, and smothering other plants. The build-up of dead material and drying off of the plant in summer presents a high fire hazard.

A reduction in density can make it easier to kill with herbicides. Fresh green growth with no seed set is essential for active uptake of herbicide. Slashing or heavy grazing early in the season may reduce seed set. Pulling or grubbing of young plants before seeds develop can help in management.

There is a very high risk of erosion in and near watercourses. Great care should be taken when weeds are removed to avoid the soil being disturbed and/or large areas left without cover.

Weed control programs should be put into place at least 18 months prior to planting, especially for perennial weed species or those that are likely to have built up a significant seed bank.

Weed competition is a great inhibitor of plant growth, and some species such as *Oxalis pes-caprae* (sour-sobs) are known to alter soil pH thereby affecting germination and growth of seedlings. In the absence of natural habitat, weeds sometimes provide the only habitat for native fauna. If this is the case, carefully staged removal in conjunction with planting new habitat will be required, particularly if there is no means for wildlife movement to other habitat areas.

Post-planting weed control may need to be undertaken if the weed levels would prevent or inhibit plant germination or growth.

Different techniques exist for controlling different weed species, including hand-pulling, cutting, grazing, competition, biological control, and use of herbicides. Professional advice should be sought when choosing to use herbicides for weed control. Various techniques have been developed to treat different types of plants with herbicide, such as spraying, cut 'n swab, stem injection, stem and leaf swabbing. It is important to understand the plant you are dealing with so that the right technique can be applied at the right time.

4.1.1 Caution: Herbicides and Watercourses Shouldn't Mix

There is a very high risk of off-target damage from herbicides around watercourses as many herbicides are toxic to aquatic ecosystems. In addition to standard best practice methods such as following the guidelines for use on the label, using dye, wearing appropriate protective clothing and only working in appropriate weather, additional care needs to be taken. Avoid spraying near a watercourse: select minimal use, direct application methods such as cut and swab or drill and fill where practical. Where spraying is necessary, such as for grassy weeds:

- Only use herbicides approved for use near a watercourse; and
- Spray away from the water and make sure the herbicide doesn't run down stems into water.

4.2 Exotic Tree And Woody Weed Removal

Exotic trees, such as Willows, Desert Ash and Hawthorn, and woody weeds such as Gorse and Blackberries, have colonised many watercourses throughout Australia, in some cases forming monocultures. They have many negative impacts on the watercourse environment including:

- Preventing light reaching the ground in summer and thereby promoting bare soil on watercourse banks, and lack of aquatic plant growth
- Dropping all their leaves over a short period in Autumn when native decomposers are unable to break the leaves down quickly enough
- Preventing regeneration of native plant species and shading out existing native plants
- Providing very little food and habitat resources for native fauna, being usually only occupied by European Blackbirds and House-sparrows.

The removal of exotic trees and woody weeds is likely to be required for most watercourse restoration projects. As for any weed control program, control work should start in the least infested areas first. Where the weeds may be providing habitat for native fauna in the absence of any other habitat, removal should be by a staged process whereby weeds are gradually replaced with native vegetation.

In most cases, trees should be killed and left standing by a method such as drill and fill[1], resulting in the least amount of soil disturbance and providing perches until revegetation matures. Removal of the entire plant is costly and should only be done if there is a risk to safety from falling branches, potential for culverts to be blocked or increasing fuel loads Woody weeds should be removed by cutting the stems and swabbing with an appropriate herbicide. potential for culverts to be blocked or increasing fuel loads. Woody weeds should be removed by cutting the stems and swabbing with an appropriate herbicide.

1 See References and Resources: Stop Bushland Weeds

4.3 Pest Control

Vertebrate pest control should be run in conjunction with weed control activities, and is essential in the establishment phase but also through the life of the project. Browsing herbivores such as kangaroos, rabbits and hares, and insect pests like Red-legged Earth-mite, caterpillars and grasshoppers may need control. Rabbit control may need to be undertaken up to two years in advance of planting, and should be ongoing. It should form part of a regional control program for most effectiveness. Control of kangaroos should be done in conjunction with NPWS. A destruction permit will be required for culling of kangaroos.

A variety of methods including non-destructive options such as fencing, planting prickly plants, distractions and change, are available. Preferential plants that are selectively grazed can be planted or sown with species that can provide innate protection. For example, species such as Drooping Sheoaks (*Allocasuarina verticillata*) that are often grazed heavily by kangaroos can be sown with species that are less palatable such as Kangaroo Thorn (*Acacia paradoxa*).

5 Establishment Techniques

Establishment techniques will depend upon the particular species being planted, the zone into which they are being planted, the terrain, available resources including budget and people, and other factors including environmental conditions. Often a combination of techniques can be used.

5.1 Machine Direct Seeding

A specialised machine is used to sow a mixture of native seed straight into the ground. This method is cheaper and easier than planting seedlings or hand-direct seeding, but timing and weed control is more critical. It is also not suited to all sites, for example those with existing trees or understorey species like native grasses. For watercourse revegetation, **machine direct seeding should only be used for pastured flats adjacent to the watercourse** (ie the C and D zones). If there is an existing tree canopy, do not seed canopy species (e.g. *Eucalyptus spp*.) beneath it.

To reduce the "hedge-row" effect that is often created by direct seeding, the seeder can be lifted at random intervals and run in wavering lines instead of parallel.

5.2 Hand Direct Seeding

Hand direct seeding is the cheapest method of active revegetation but can have variable results. This method involves preparing the site for seeding by lightly raking a small area into which seed is scattered and, if the seed is large, covering seeds with soil.

Hand-seeded spots can be sheltered with fallen branches to protect emerging seedlings from browsing, or to minimise the potential for seeds to be washed from the soil during rain or windy events. Hand direct seeding can be used in a range of situations, including establishing sedges and rushes on damp and sloping soils adjacent to a watercourse. Hand broadcasting whole seed-heads of native grasses has also been known to work.

5.3 Tubestock Planting

A wider range of species can be established by tubestock than direct seeding methods. Tubestock planting is especially useful for

- slow growing species such as Yaccas and Banksias,
- cutting-grown species such as Hop Goodenia and Lignum, and
- species for which little seed is available, such as the Hakeas.

For this reason, tubestock planting can be used to supplement direct seeding, or as a method on its own. Along watercourses, tubestock planting is especially useful for planting the banks.

Numerous contractors and nurseries collect and propagate local native seed for planting at a site, but growing your own seedlings is cheaper and can be very rewarding. The GWLAP is able to assist with advice in this regard. Some species are better propagated by cuttings, or by dividing clumps, instead of from seeds due to poor germination rates or a lack of knowledge on germination techniques for that species.

Costs depend on the amount of seed to be collected and number of plants to be grown, availability of seed and difficulty of propagation, age of seedlings and the size of the tube the seedlings are grown in. Tubestock planting is the most costly and labour intensive method of revegetation but also the most reliable.

Tubestock planting is undertaken following the first good break-of-season rains, usually from June until as late as September depending on the rainfall and soil moisture.

5.4 Collecting Seeds and Cuttings

The collection of native plant material (seed, fruits, cutting material or bulbs) is governed by the *National Parks and Wildlife Act* 1972 which is administered by the Department for Environment and Heritage. If you wish to collect seed or propagation material from public land such as Forest Reserves, NPW Reserves, Crown Land, and other public land such as roadsides and local council reserves, you will need to obtain a seed collection permit from the Minister for Environment and Conservation, through DEH, and the permission of the landholder.

Seed or propagation material collected from private land requires the permission of the landholder, but you do not need a permit to collect seed or take cuttings from plants on your own property. There are several conditions to this, for instance if the plant is a rare plant (listed in Schedules 7, 8 or 9 of the Act) a permit is required regardless of whether you have the permission of the landholder or if it is on your property. It is best to contact DEH prior to collecting seed or propagation material.

5.5 Comparison of Establishment Techniques

	ESTABLISHMENT METHOD			
SITE ISSUES	**Natural Regeneration**	**Hand Direct Seeding**	**Machine Direct Seeding**	**Seedling Planting**
Too steep for vehicle access	✓	✓	X	✓
Rocky, shallow soils	✓	✓	X	? – Often hard to find enough soil to plant in
Boggy, wet soils	✓-Often a lot of weeds	✓	? – Only once site dries out enough	✓
Establishing common species (Eucalypts, Wattles, Sheoaks etc)	✓	✓	✓	✓
Establishing rare, large seeded or hard to collect species	✓- Depends what seed is present	? – Good for annuals	X	✓
Establishing native grasses	✓- Can use grazing, slashing or burning	✓	? – Not with conventional direct seeding machine	✓
Small site (<1ha)	✓	✓	? – Not always economical	✓
Large site.	✓	✓	✓	? - Costly for large sites
Some native vegetation present (eg grasses, trees)	✓	✓- Careful weed control	X	✓- Careful weed control
Highly modified site (eg cropped or introduced pasture, regularly fertilised)	X- Some Eucalypts may regenerate but little else	✓	✓	✓
Budget	$	$$	$$$	$$$$

6 Species Selection

6.1 Selecting the right species to plant in the right place

Only species that are native to the local area should be used to revegetate watercourses, a list of revegetation species is provided with this booklet for each of the areas described in section 1.2. These species lists should be considered a guide only and landholders should seek advice from LAP project officers or revegetation consultants to develop species lists specific to their property. Not all the species for each area need to be planted into every site as this will vary from property to property depending on what existing native vegetation remains on site.

Take note of where each species naturally occurs. Within the riparian zone are sub-zones of differing moisture levels. Different species grow in each of these sub-zones; for the purposes of this report these are referred to as zones A – D (see table below). Figures 1 and 2 illustrate the location of these zones depending on whether the site is a seasonal or permanent watercourse. Assess which sub-zones are present along the watercourse and then select species appropriate to those sub-zones.

ZONE	DESCRIPTION
A	Water's edge & swampy areas
B	Lower Banks
C	Upper banks and floodplain
D	Well drained soils on floodplains

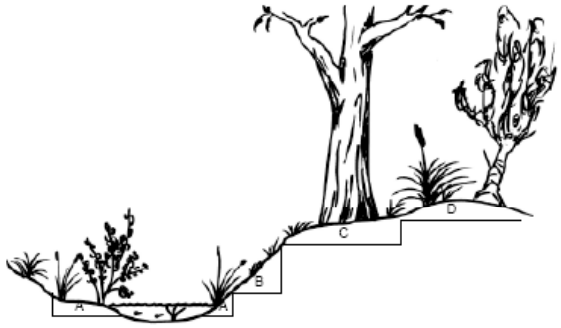


Figure 1. Showing riparian sub-zones for a creek with permanent to semi-permanent pools

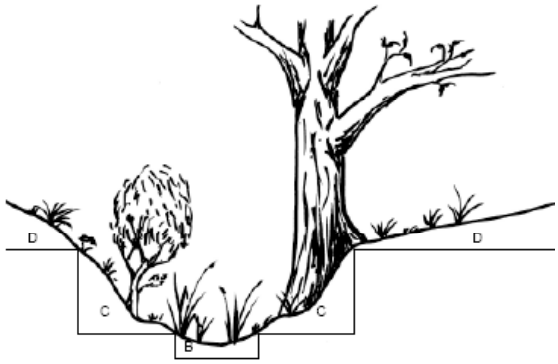


Figure 2. Revegetation zones for a seasonal watercourse.

6.2 Using Locally Collected Seed

For all revegetation work including habitat restoration, the use of seed collected from locally occurring native species is highly recommended. This is sometimes referred to as local provenance seed. Local species are particularly adapted to the climatic and physical conditions of a region. The use of local species maximises the chance of restoring plant - animal interactions such as pollination and seed dispersal.

Collect seed from within the nearest possible remnant or from the nearest possible remnant with a similar soil type. If collecting seed ensure that seed is taken from a variety of sources, not just one plant. Taking seed from across several plants of the same species helps to maintain the genetic diversity. LAP officers and suppliers of seeds or seedlings can help prepare a species list for your site.

6.3 Ordering Seed and Seedlings

Regardless of the purpose of the planting, it is important to consider that, depending on which species you wish to use, you may need to order at least six months if not up to two years in advance of planting. Some species can be difficult to propagate, or take a while to germinate, and for others seed availability may determine whether plants are available in a particular year.

6.4 How Many of Each Species?

The number of plants to use per hectare can vary greatly depending on the particular site features (eg. a very rocky site with minimal topsoil will differ from a site with deep, loamy soil), existing flora, cost, time, climatic variables like low rainfall zones, and the type of plant association you are trying to re-establish or enhance.

For heavily modified sites with very little native vegetation, consider approximately 1000 plants per hectare as a minimum. Ideally, groundlayer grasses, sedges, rushes and reeds should be planted in the greatest numbers at densities around 10,000/ha, however, the costs and labour involved is usually prohibitive. An alternative is to plant as many as possible in patches across the site, and in between plant densely with fast growing coloniser species to suppress introduced grassy weeds and create an environment more favourable to native species. Most of the coloniser species are short lived, so while the revegetation may be very dense for the first few years, it will begin to thin out over time. The density for understorey species will be dependent upon the purpose of the planting and type of plant association; if you are attempting to provide nesting resources and shelter for cryptic species, then the number of species and plants used may be quite high. Cryptic species are those that might be hard to see due to their colourings or behaviour, such as Australian Painted Snipe, or Flycatchers. Except for heathy, stringy-bark sites, the number of overstorey Eucalypts should be less than 200 per hectare, unless there are already overstorey trees on site, in which case this should be reduced further to <50, or none at all.

6.5 Creating Patchiness and Structural Diversity

Establish layers of vegetation by planting diversely; structural diversity maximises available resources for native fauna. Include upper canopy, understorey and groundcover vegetation and create patches within each layer. Different types of species within each layer provide different resources also; rough-barked trees such as stringybarks and Peppermint Box provide habitat under loose bark for invertebrates that are food for lizards, birds and other animals. A lack of understorey plants can favour aggressive "increaser" species such as Noisy Miners, which can displace less-aggressive species.

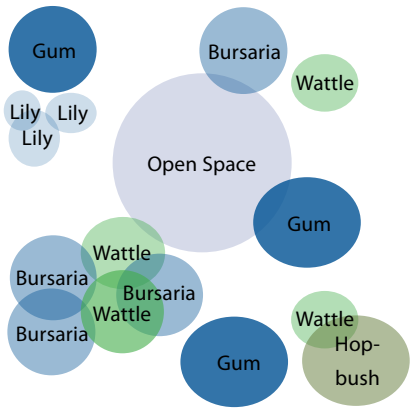
Consider, if you are trying to mimic neighbouring remnants, **what type of habitats and plants occur naturally.**

For example, if the area is naturally grassland, work with this rather than trying to create closed woodland. The area may naturally have had minimal trees.

Habitat features such as **dead trees with hollows should be retained** as these provide nesting and perching resources for many woodland birds and birds of prey. Ground-layer features such as logs, rocks, cryptogams (lichens and mosses), leaf litter, low vegetation and open spaces provide habitats suitable for a variety insects and animals such as lizards. Larger predatory species are in turn dependant upon these smaller animals. Such habitat features also encourage soil fauna and fungi to develop, many of which are needed for healthy vegetation (such as mycorrhiza fungi), as well as microphytic crust that help reduce soil erosion.

Where feasible, avoid neat rows of regularly spaced plants – **in natural environments plants are spaced unevenly**; revegetation for biodiversity should attempt to mimic this, as it provides the best opportunity for a suite of fauna species rather than restricting to a few, by providing a diverse range of habitats. For example, open grassy areas provide habitat for robins and bird-of-prey such as kestrels, while more closely spaced vegetation provides habitat for more secretive species such as thornbills and wrens.

Example of a planting layout that creates a variety of densities and structures.



7 Biodiversity Enhancement and On-going Maintenance

7.1 Management

Pest plant and animal control programs should be continued over time. Control of a range of pest plants and animals is 'prescribed', meaning it is the responsibility of the landholder to undertake control programs. Many environmental weeds such as Phalaris can quickly invade and overtake planting sites, particularly if stock has been excluded. Monitor the site for the invasion of new weeds, such as Bridal Creeper (Asparagus asparagoides) or Olives (Olea europaea ssp.), which may be brought into the site as fruit eating birds perch on overhead branches and unintentionally distribute the seeds.

7.2 Planting Over Multiple Years

Where the aim of the project is to try and mimic remnant native vegetation, it is best to undertake planting of one site over several years. Often watercourse sites are too weedy to establish grasses and other small species in the first year as they become over-grown by weeds, hard to find and are accidentally removed during maintenance weed control. Instead, consider establishing such species in following years when aggressive weeds have been reduced.

Undertaking shrub and canopy planting over several years will encourage the development of different age classes, mimicking natural succession. However, seedlings planted into already revegetated sites will be susceptible to moisture competition from the existing plants, and survival may be reduced in low rainfall seasons.

7.3 Biodiversity Enhancement Techniques

More species can be planted to increase the diversity of habitats, vegetation structure and species, especially as weed levels reduce and the site becomes more suitable for small native species. The site can be further manipulated by removing trees altogether to open areas up (beware that this may encourage weed growth), or coppicing trees to create new waves of growth and multi-stemmed trees.

Habitat features that may develop over time, such as dead trees, should be retained as these provide nesting and perching resources for many woodland birds and birds of prey. Ground-layer features such as logs, rocks, leaf litter and open spaces provide a variety of habitat features for invertebrates and lizards, providing habitat and resources not only to those species but also the species that are in turn dependent upon them. Nest boxes may be attached to larger trees until they are old enough to form their own hollows.

7.4 Monitoring

Monitoring can be as detailed or as simple as you like and can include qualitative (photopoints) and quantitative (measurable) methods. For example, photopoints can provide a 'snapshot' of vegetation change over time, while survey transects provide specific information related to species presence / absence and abundance. Recruitment of plant species, or fruiting and seeding events, can be useful indicators of plant health. Lack of fruit or seed may indicate a lack of suitable pollinators, either bird or insect, but can also be a response to seasonal conditions.

Water quality monitoring may provide useful information on the effectiveness of the project and the health of the catchment if standard methods are used. Consider monitoring water upstream and downstream of the protected watercourse.

Observational records of fauna use, such as birds, reptiles or mammals, may also indicate whether the planting is providing habitat for such species – often a secondary benefit. Such species can be important aids in controlling insects and other pests.

There are a range of monitoring techniques and datasheets, many of which can be found freely on the Internet, or through community groups or project officers. Monitoring as part of a broader program using standard methods will provide the most useful results. Contact the SA Murray-Darling-Basin NRM Board to find out what monitoring programs you can join.

8 Calendar of Revegetation Activities

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Ideally all revegetation activities should be planned well in advance of them being undertaken. Timing will depend on your rainfall area, and the local environmental conditions.

- Begin planning two or more years ahead of seeding or planting
- Start weed control at least 12 months prior to seeding or planting, or earlier depending on the site and the nature of the weeds
- Order seed two years before seeding or planting
- Order plants at least 12 months prior to planting

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8 Calendar of Revegetation Activities

	YEAR 1				YEAR 2				YEAR 3
ACTIVITY	Sp	Su	Au	Wi	Sp	Su	Au	Wi	
1. Planning									
Determine the area that you plan to revegetate. Work out site specific factors such as: - Tubestock / seed requirements (species, quantities) - Proposed weed / animal control programs - Fencing needs - Local growers / contractors									
2. Weed Control									
Spray out rows / spot spray for tubestock or hand direct seeding									
Re-spray rows if re-growth, 2-6 weeks prior to planting									
Spray around seedlings or between planting rows									
Control woody weeds and exotic tree									
3. Pest animal management									
Pest control									
Undertake coordinated whole-of-property and preferably region control program									
Fencing									
Fence off area and exclude stock									
4. Seeds and seedlings									
Seed collection, cleaning and ordering									
Get in touch with contractors / growers to confirm seed and seedling									
Plant orders and propagation									On-going
5. Revegetation									
Direct seeding and planting									
Undertake seeding and / or tubestock planting									On-going
6. Maintenance									
Monitor for snails, rabbits / hares, weeds									
7. Monitoring									
If necessary, slash between rows and / or overspray with grass-selective herbicide									(Winter)
7 Ongoing									
Continue to control weeds, pest animals and other site specific actions, such as maintaining fences to exclude stock									(Ongoing for life of project and beyond)

9 Useful References

9 USEFUL REFERENCES

Note that many of the references listed below are available through the Mt Barker Natural Resources Centre.

9.1 MANAGING WATERCOURSES

- Abley, A., Cantono, D., Pickett, M., Smith, G., Stevens, A. & Vale, T. (2007) *Protecting Fleurieu Peninsula Swamps and the Mount Lofty Ranges Southern Emu-wren: A Guide for Landowners, Land Advisers, Property Planners and Developers,* Mt Lofty Ranges Southern Emu-wren and Fleurieu Peninsula Swamps Recovery Team, Adelaide.
- / Land & Water Australia *River Landscapes* Fact Sheet series, www.rivers.gov.au
- Land, Water & Wool: www.landwaterwool.gov.au.
- Staton, J. & O'Sullivan, J. (2006) Stock and Waterways: A Managers Guide, Land & Water Australia, Canberra.
- Upper Torrens Landcare Group Inc. (2003) *Watercourse Management: A Field Guide for the Mount Lofty Ranges*, Third Edition.

9.2 WEED CONTROL

- / CRC for Australian Weed Management (2004) Introduction to Weed Management - Module 1: Developing and Implementing a weed management plan, www.weeds.crc.com.org.au.
- EPA South Australia, *Safe and Effective Herbicide Use: A Handbook for Near-water Applications.*
- Robertson, M. (1994) Stop Bushland Weeds – A Guide to Successful Weeding in South Australia's.

9.3 NATIVE PLANT IDENTIFICATION

- Dashorst, G. R. M. & Jessop, J. P. (2006) *Plants of the Adelaide Plains and Hills*, The Board of the Botanic Gardens of Adelaide and State Herbarium, Adelaide.
- Prescott, A. (1988) *It's Blue with Five Petals: Wildflowers of the Adelaide Region,* Ann Prescott.

9.4 REVEGETATION DESIGN & METHODS

- Platt, S.J. (2002) *How to plan wildlife landscapes: a guide for community organisations.* Department of Natural Resources and Environment, Melbourne.
- Dalton, G. (1998).*Creative Revegetation - Enhancing biodiversity by design*
- NCSSA (2000) Factsheet *Biodiversity*
- PIRSA (2005) Factsheet *Windbreaks*
- Martin (1999) Fact Sheet - *Natural Regeneration of Native Vegetation*
- Rural Solutions SA (2003) Fact Sheet – *Direct Seeding* (Rural Solutions SA, 2003)
- PIRSA (1998) Fact Sheet – *Hand Direct Seeding of Native Plants* (PIRSA, 1998)
- Murphy and Martin (1999) Fact Sheet - *Seed Pre-treatments for Native Understorey Species*

9.5 HOW TO COLLECT AND GROW SEED

- Bonney, N. (2003) *What Seed is That?* (Revised Edition), Finsbury Press.
- Dean, J. (2002) *Hand Direct Seeding of Native Plants*, Primary Industries & Resources SA Factsheet.
- Florabank Guidelines: http://www.florabank.org.au/
- Greening Australia *How to collect native tree seed, easily*
- Dalton, G. *Direct seeding native trees and shrubs*

10 Appendix: Revegetation Costs

Guide only, landholder may supply own labour for many of these therefore costs would come down

ITEM	YOUR PROJECT ESTIMATES
Fencing: $3,500 - $8,000/km+ materials and labour (depends on type of fencing and number of bends)	
Pre-planting weed control: $0.40/spot for tubestock or hand direct seeding (usually 1,000 spots/ha) $200/ha for rows for machine direct seeding, (usually 1.5km of rows/ha)	
Seed/Plants: $0.80 - $2.50/seedling if ordered at least 6 months in advance, (usually 1000 seedlings/ha) $200-300/kg for machine direct seeding mix, (usually 1.5kg/ha for machine direct seeding)	
Seeding/Planting: $100/ha for machine direct seeding (depends on size of area) $0.40 - $1.00/seedling to plant (depending on access and soil type)	
Plant Protection: Red-legged Earth-mites (RLEM) and/or snails may need to be controlled for machine or hand direct seeded sites, allow $100/ha for snail baiting at the time of seeding, and $50-$100/ha for RLEM depending on accessibility. Guards may be required for seedling planted sites, allow at least $0.40 - $2.00/guard, plus stakes.	
Post-planting Weed Control: $0.40/plant	