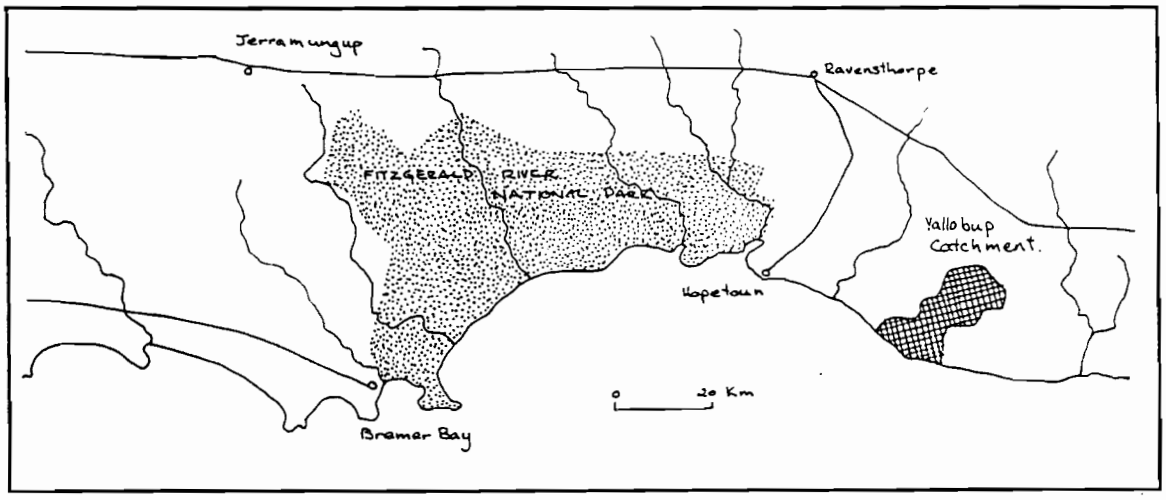
Yallobup Creek Catchment Study

Strategies for Balanced Water Use

compiled for the
Ravensthorpe Land Conservation Committee
by Ted Lefroy
April 1989



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Contents

Introduction

The irony in Australian agriculture is that for such a dry continent the increasing problem of salinity is due to an excess of water.

Agriculture in Southern Australia has involved replacing the original deep rooted perennial vegetation with shallow rooted crops and pastures that are actively growing and using water for only four or five months of the year.

These crops and pastures use less water than falls each year as rain and each year a surplus is added to the ground water reserves. In Southern Western Australia this annual addition has been estimated at 20 to 50 mm per year, or 5 - 10% of the annual rainfall (Peck and Hurle 1973).

Over many years this recharge causes groundwater levels to rise. As it rises it brings with it dissoved salts laid down over thousands of years in the clay subsoil. In the Yallobup* catchment, these salt reserves have been estimated at between 200 and 5000 tonnes of salt per hectare of land (Nulsen 1986).

The source of that salt is the sea. The strong westerly winds of the roaring forties carry inland up to 100 kg per hectare of chloride ions each year onto the south coast (Hingston and Gailitis 1976). This amount decreases to 50 kg at 30 km and 20 kg at 150 km from the sea. This travels as aerosols of sea salts and with a similar amount of sodium being carried, this is roughly equivalent to 200 kg of salt deposited on each hectare of land. This is among the highest value recorded anywhere in the world, and compares to levels from the west coast of Ireland and Norway, also in the path of strong winds from the ocean.

At those rates of deposition it would take at most 25 000 years for the high levels of salt to accumulate in coastal areas. Much more recent than the 40 million years since this part of the south coast was under the Oescene Sea at the time Australia separated from Antartica.

This process of farm land salination resulting from the cycling of sea salt and the removal of native vegetation was first put forward by a railway engineer, concerned with the corrosive effects of increasingly saline water on steam boilers (Wood 1924).

An estimated 315 000 hectares of land in Western Australia are affected by salinity at present (Western Australian Department of Agriculture Annual Report 1988). This represents 2% of the area of the state cleared for agriculture. A further 2.4 million hectares of land is considered at risk and becoming saline at a rate of

* Also referred to as the Jerdacuttup Catchment. This name has been adopted to avoid confusion with the catchment of the Jerdacuttup River to the west.

between 10 000 and 20 000 hectares per year.

In the Yallobup Catchment, 4% of the cleared land is affected by salinity (1000 ha) and a similar area is affected each year by waterlogging.

In 1986 the Department of Agriculture conducted the Jerdacuttup Catchment Land Resource Study (Moore, Vincent and Gee, 1986). This study of soil types and landforms produced a map that used over 20 mapping units to describe the catchment. For the purpose of recommending different management strategies, these have been amalgamated into 6 groups as follows. A colour code is suggested to assist in identification on the accompanying map.

Colour	Soil	Map Units Represented
Red	Saline	I5, Cy, Oy
Yellow	Deep Sands (80 cm+)	G3, L3, D1, G8
Blue	Poorly drained, non saline	I1, I2c, I4, I7, Cf, Of
Green	Level duplex soils (less than 30 cm sand)	L1
Orange	Sloping, shallow duplex soils (less than 30 cm sand)	G1, G6
White	Medium duplex soils (30 - 80 cm sand)	L2, L2c, L4, G2

Soil Grouping by management class.
Table 1

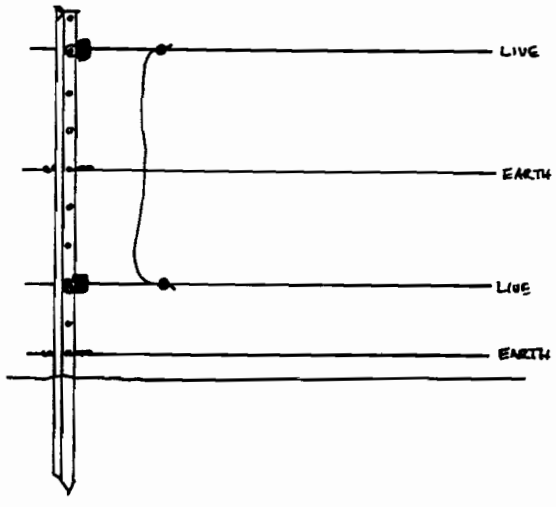
The management strategies recommended are all concerned with maximising water use with plants. These fall into the following categories.

- perennial and annual pasture mixes for recharge and discharge areas.
- fodder trees and shrubs for recharge and discharge areas.
- water pump trees to lower saline water table.
- trees and shrubs for shade shelter and revegetation with emphasis on local species.
- agroforesting combinations of trees with crop rotations and pastures.

The high water use options involve mainly perennials which means they are slow to establish, and therefore costly to establish. For that reason, mixtures of species have been recommended throughout as better protection against pests, diseases and extremes of weather.

1. *Fencing*

The first step to managing these different groups to make the best of their characteristics is to separate them from one another. As soil type boundaries don't follow straight lines, the fences will need to accommodate a lot of bends. With conventional high tension fencing, each bend requires a strainer assembly which adds time and cost to the fencing. A flexible and effective solution that is relatively inexpensive is the electric fence illustrated below.



Materials required per kilometre
4 km plain wire (2.5 mm)
50 galvanised posts (1600 mm)
100 insulators
4 end insulators
switches and ug cable
1 end assembly

4 wire electric fence approximate cost $500/km
Fig.1

Posts should be spaced about 20 metres apart with clip-on polypropylene insulators for the live wires. The live wires should be connected to each other once every kilometre with 2.5 mm underground cable. At every junction where the current heads off in different directions there should be a switch to isolate each branch to make fault finding easier.

A quick way to identify faults from a vehicle when driving beside an electric fence is to tune the car radio to the left hand end of the dial (500 to 600 kHz), turn the volume full up and listen for a change in strength of the fence pulse which should be picked up by your radio. A short circuit in the fence will result in a lower signal at that point. This can be checked with a voltmeter.

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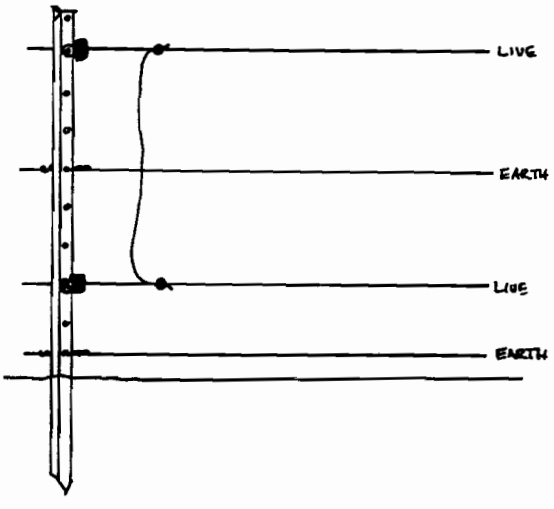

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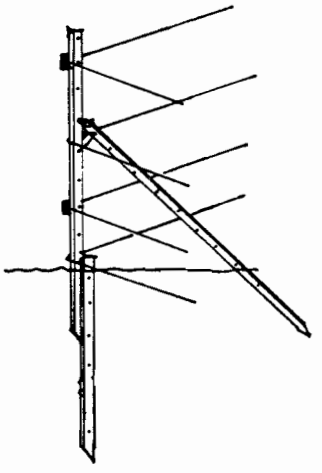
Electric fences have been responsible for starting bush fires. A way to lessen this risk considerably is to install a timer switch between the energiser and the power source. On days of high fire hazard, set the times to disconnect the power during the time of greatest risk, say 8 am to 6 pm. On days such as this stock are unlikely to put fences under much pressure.

To negotiate bends when fencing to soil type, following drainage lines and isolating areas of remnant vegetation. The half post underground is only necessary in deep sand.



Electric fence corner assembly

Fig. 2

The lift up gate shown in Figure 3 allows a wide opening which reduces erosion risk and allows quicker stock movement. Materials required are 6 full length galvanised posts, a 5 metre length of high tensile steel tubing and one cut down post. The proportions of width to height are important for a well balanced lift.

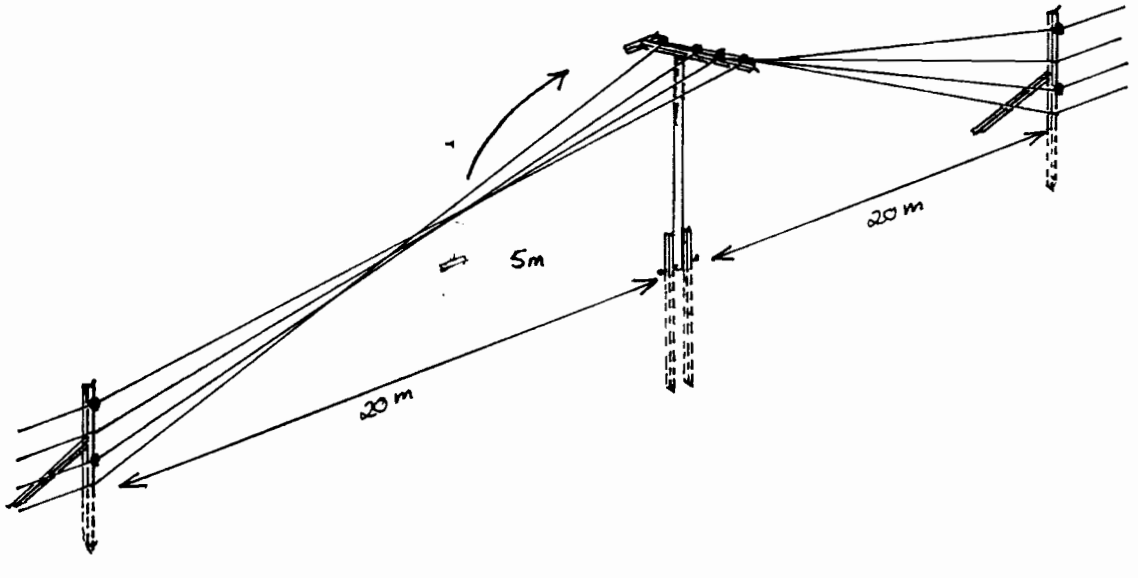


Fig. 3 **Lift up gate**

2. *Saline Soils*

The various options for managing saline soils are to

- fence off and encourage natural regeneration
- plant the area to a mixture of salt tolerant native trees and shrubs
- plant to high water use salt tolerant trees at a wide spacing that will reduce the salinity and allow grazing or cropping between the trees
- plant to salt tolerant fodder shrubs like saltbush and bluebush.

These are described in increasing order of cost.

Natural regeneration

Fencing alone to control grazing and reduce stock damage will allow a natural cover of barley grass and other salt tolerant annuals to establish. Salt tolerant native plants will then slowly recolonise such areas from seed remaining in the ground and carried in by wind and birds. This process can be further encouraged be increasing the supply of seed and reducing competition from introduced pasture and weed species. On mildly saline sites, weed control can be achieved by grading strips across the area at intervals on the contour to a depth of about 5 mm to remove weed seed, or if there is dead timber available, localised hot fires that will kill seed in the soil to that depth. Carting in cut branches with ripe fruit to these areas will provide a source of seed. The ashbeds and graded strips will provide a seed bed. Weed control can also be achieved by spraying with Sprayseed® or Roundup® at 1 L/ha in strips. Local sources of seed for these areas are shown in Table 1.

		Endemic to the Catchment
ST	*Eucalyptus*	*famelica* (Green Salt Mallee)
ST		*occidentalis* (Swamp Yate)
SST		*platypus var. Heterophylla* (Coastal Moort)
ST	*Melaleuca*	*cuticularis* (White Paperbark)
SST		*brevifolia* (Small Saltwater Paperbark)
SST	*Acacia*	*saligna* (Coast Wattle)
SST		*cyclops* (Wattle)
		Introduced
SST	*Eucalyptus*	*spathulata* (Swamp Mallee)
ST		*sargentii* (Salt River Gum)
ST		*camaldulensis* (Red River Gum var. Lake Albycutya)
ST	*Callistemon*	*phoenicius* (Bottle brush)
ST	*Allocasuarina*	*obesa* (She-oak)

Local seed sources for saltland regeneration
Table 2

ST = Salt tolerant
SST = Slightly salt tolerant (see Table 17)

Cost: fencing only - $125-$150/ha

chemical weed control - $8-$20 per sprayed hectare.

Planting back to bush

A less haphazard but more expensive way of returning salt land to bush is to re-plant the area with seedlings or by direct seeding through a special purpose tree seeder. Seedlings planted into saline soil require a seed bed raised 20 to 30 cm above ground level to both allow rain early in the season to leach some of the salt and also to reduce the risk of waterlogging often associated with saline sites. Ripping to 50 cm to penetrate hard pan should be carried out before mounding. Weed control is necessary over these mounds and can be achieved with Roundup® or Sprayseed® at 1 L/ha or Vorox® at 4 L/ha. Seedlings should be planted at intervals of 5m. Planting seedlings limits the range of trees and shrubs to those commercially available and includes few of the salt tolerant species endemic to the area. In addition to the list of trees given above, those in Table 3 are suitable for the area.

ST	*Eucalyptus*	*famelica* (Green Salt Wattle) local
SST		*halophila*
ST		*occidentalis* (Swamp Yate) local
SST		*spathulata* (Swamp Mallee)
SST		*playpus var. Heterophylla* (Coastal Moort) local
ST		*sargentii* (Salt River Gum)
ST		*camaldulensis* (Red River Gum var. Lake Abacutya)
SST		*kondininensis* (Kondinin Blackbutt)
SST		*rudis* (Flooded Gum)
SST		*botryoides* (Southern Mahogany)
SST		*megacornuta* (Warty Yate)
SST	*Acacia*	*saligna* (Coast Wattle) local
SST		*cyclops* local
SST		*redolens* (Vanilla Wattle)
ST	*Melaleuca*	*cuticularis* (White Paperbark) local
SST		*brevifolia* (Salt Water Paperbark) local
SST		*hamulosa* (Tea Tree)
ST		*thyoides* (Tea Tree)
SST		*acuminata* (Tea Tree)
SST		*spathulata* (Tea Tree)
ST		*halmaturorum* (Kangaroo Tea Tree)
SST		*rhaphiophylla* (Swamp Paperbark)
SST	*Allocasuarina*	*obesa* (She-oak)
ST	*Callistemon*	*phoenicius* (Bottlebrush)

Salt Tolerant Trees and Shrubs for Revegetation
Table 3

Eucalyptus	150 g
Acacias	250 g
Melaleucas and Callistemons	50 g
Allocasuarinas	50 g
Superphosphate	125 kg

Proportions for a Direct Seeding Mix sufficient for one hectare
Table 4

Direct seeding, while allowing for a wide range of species, is still a very risky proposition, even in non saline soils with timing of rainfall after seeding and after germination being critical for survival. As with seedlings the seed bed should be raised and spraying is necessary to control weeds. Residual herbicides will reduce germination so only Roundup® or Sprayseed® should be used. As raising mounds wide enough for a combine is difficult and expensive, a single low seeder should be used, and the seed only very lightly covered (such as by dragging brush or carpet behind seeder) or left uncovered. The Mallen and Kimberley seeds make seeders that have been designed for saltbush. Seeding will build the mound and seed in one operation. Until the risk involved with small seeds is reduced such as by clay pelleting of seed, direct seeding should be seen as an experimental option for these soils. Its advantage is the variety of plants that can be established and seed of these species can readily be bought or collected.

As seed size and weight varies with species, the following proportions are suggested for a seedling rate of 500 g/ha with a mixture of trees and shrubs.

A rate of 500 g/ha of seed is suggested although good results have been achieved with 350 g/ha locally. Roadside revegetation by Main Roads is carried out at the rate recommended by CALM of 1 kg/ha. As a guide to seeding, a 5 m wide combine will cover one hectare every 2 kilometres planted.

Superphosphate will not inhibit germination or growth of the native plants in the table above but should not be used with any plants of the Proteacae family (Banksias, Grevilleas or Hakeas).

Cost:

Fencing	$125 - $150/ha
Chemical weed control	$8 - $20/ha
Plant seedlings	$150 – $200 per km row
Direct seed	$150/kg seed mix (or $75/ha by combine)
Contract direct seed	$100 - $120/ha ($50 - $60/km of rows)

Water Pump Trees for Agroforestry

Tree planting on saltland near Mr Ray Walters' property at Brookton by the Department of Agriculture has shown the benefit of low density planting of selected high water use salt tolerant trees in reducing salinity and allowing cropping or grazing between the rows (Engel and Negus, 1988). Planted at only 80 trees per hectare, trees lowered a rising saline water table (8000 ppm) by 75 cm in six years. A workable layout to achieve that density is shown below.

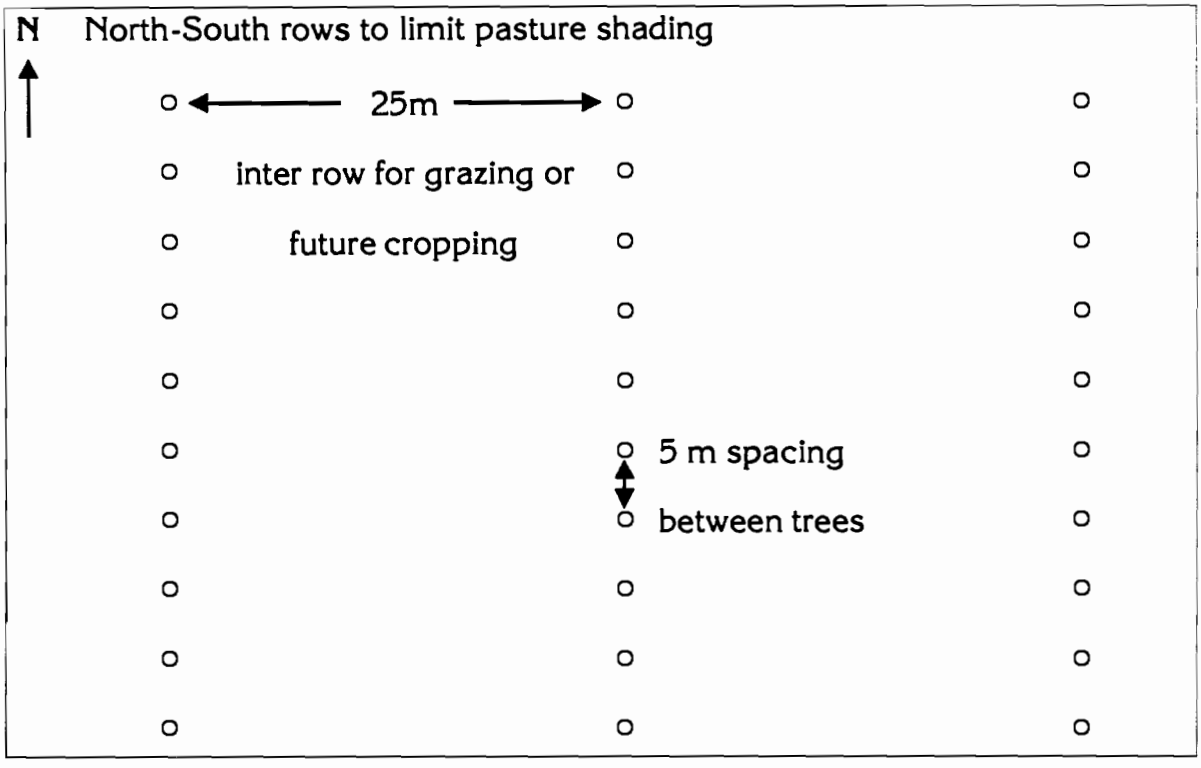


Fig. 4 **Agroforestry layout for salt land**

Rows need to be ripped to 50 cm to penetrate hard pan and mounded with a plough or grader to lift the seedlings clear of waterlogging by 20-30 cm and to allow rain to leach some of the salts from the row. Weed control can be achieved with a metre wide spraying of Roundup® or Sprayseed® (1 L/ha) or Vorox®* (4 L/ha). The local Swamp Yate (*Eucalyptus Occidentalis*) was one of the best performers in this trial. Two year old Swamp Yates have been measured by the CSIRO at Popanyning (420 mm rainfall) to use 20 litres of water per day on average. Three years should be allowed for trees to establish before grazing.

* Simazine/Atrazine herbicides are now banned in the USA and parts of Europe and may well be banned in Australia in due course.

Existing Ground Cover	Water Pump Tree
Bare (Possible choices - water use not known)	*Eucalyptus famelica* (Green Salt Wattle) *Allocasuarina obesa* (She-oak) *Tamarix spp* (Tamarisk)
Light Barley Grass	*Eucalyptus occidentalis* (Swamp Yate) *sargentii* (Salt River Gum)
Thick Barley Grass	*platypus var. heterophylla* (Coastal Moort) *kondininensis* (Kondinin Blackbutt) *camaldulensis* (River Gum var. Lake Albacutya) *spathulata* (Swamp Mallet)

Water Pump Trees for Saltland Agroforestry
Table 6

Cost:

Fencing	$125 - $150/ha
Plant seedlings	$60/ha
Weed control	$8 - $20/ha
W-drains where necessary	$150/ha

Fodder Shrubs and Pastures for Saltland

A lot of research and trial work by the Department of Agriculture (Malcolm, C.V.) and private companies has gone into revegetating saltland in the last ten years. The picture we have now is the possibility of a range of pasture species, shrubs and trees for forage as well as the salt tolerant water pump trees described in the last section.

By combining rows of taller forage shrubs and trees with an inter row of grasses, saline soils can provide shade, shelter and feed while supporting a high water use cover.

Inter row

Puccinellia Ciliata is a perennial salt tolerant grass that will tolerate winter waterlogging. The most important factor in establishing *Puccinellia* is to minimise competition from barley grass. To do this it will be necessary to restrict seed set the year before by grazing or spray topping, or killing the barley grass that has set by burning in the autumn prior to seeding. The barley grass that does germinate with the opening rains should then be sprayed with Sprayseed® at 1 to 2 L/ha depending on cover. The *Puccinellia* seed can then be mixed with superphosphate at 2 - 4kg seed plus 125 kg super/ha and sown through the fertiliser box of a combine. Once germinated the *Puccinellia* will need almost two years to establish before grazing - that is until the second autumn after planting.

Paspalum Dilatatum, commonly called paspalum, is a perennial grass that is less tolerant of salt and winter waterlogging than *Puccinellia*. It can be a very useful pasture species where thick barley grass is evident and is able to take advantage of the significant summer rain in the southern half of the catchment. It can be sown in the same way as *Puccinellia*.

Paspalum Vaginatum is also known as Salt Water Couch or Saltene® and is a very salt tolerant fine leaved couch commonly used for lawns. It will tolerate water up to 14 000 ppm salt and is established along drainage lines and low lying areas in the southern half of the catchment. As seed of saltwater couch is not available it can only be established by sods or runners which best pressed or trodden into ploughed furrows.

	Bare to light Barley Grass prone to flooding	
Rows	*Tamarix*	*aphylla* (Athel Tamarisk)
		parviflora (Early Tamarisk)
		pentandra (Late Tamarisk)
		gallica (French Tamarisk)
	Allocasuarina Obesa (She-oak)	
Inter Row	*Puccinelliaciliata* (Puccinellia)	
	Paspalum vaginatum (Salt Water Couch)*	
	Light to Thick Barley Grass occasionally or never flooded	
Rows	*Atriplex*	*amnicola* "Rivermoor" (River Saltbush)
		undulata (Wavy Leaf Saltbush)
	Allocasuarina obesa (She-oak)	
	Acacia	*saligna* (Coast Wattle)
		cyclops
		redolens (Vanilla Wattle)
	Maireana	*brevifolia* (Blue Bush)
	Agropyron elongatum (Tall Wheat Grass)	
Inter Row	*Puccinellia ciliata* (Puccinellia)	
	Paspalum dilatatum (Paspalum)*	

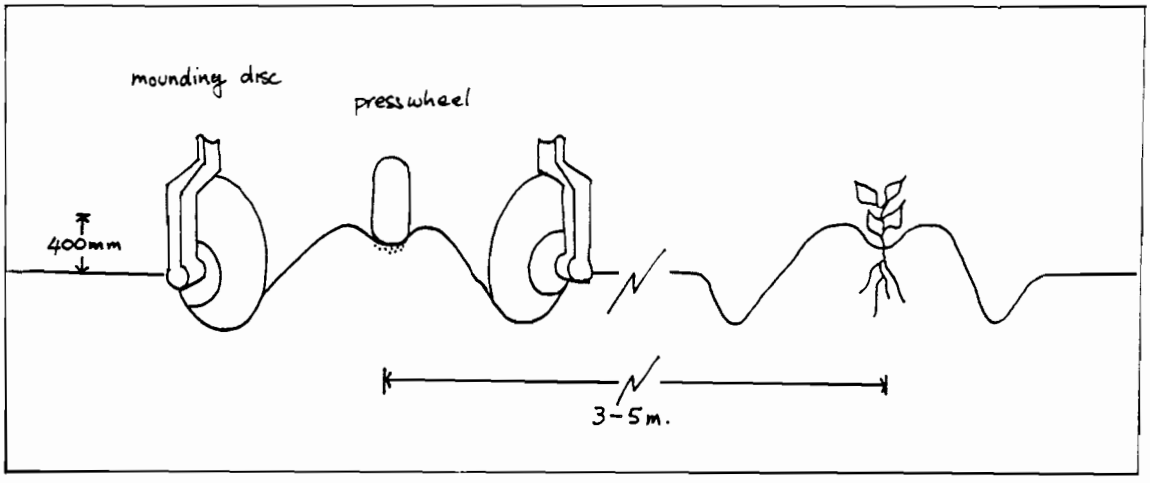
Salt Tolerant Combinations for Fodder and Water Use
Table 7

* Southern half of catchment

Rows

The taller salt tolerant trees and shrubs are best sown in rows 5 m apart or wider for 3 reasons

- seeds and seedlings will do better in a raised bed that is partly leached of salts.
- grazing management and mustering are easier when the trees and shrubs are concentrated in rows.
- shading of the inter-row pasture is lessened, particularly if rows are planted north-south.



The Niche Seeding Technique. *Fig. 4*

Bare to light barley grass

In these areas, especially when prone to flooding, the rows of trees and shrubs are best planted as seedlings or cuttings. The tamarisks can be grown easily from cuttings. The longer the cutting the better the chance of strike and a manageable size is 40-50 cm with only the top 10 cm protruding out of the soil. Cuttings should not be less than 1 cm diameter. A good guide is to make them about the thickness of your little finger.

Tamarisks have been used for over thirty years for revegetating bare saltland in Western Australia. *Tamarix aphylla* and *T. gallica* are both evergreen, the first being a tree and the second a shrub from 2 to 4 metres high. The other two are deciduous and their names (late and early) refer to time of flowering. They are eaten by sheep and *T. aphylla* has shown 54% digestibility and 15% protein on analysis by CSIRO (Downes, 1987).

She-oaks are best planted as seedlings. As well as providing wind protection for bare salt areas the she-oak and tamarisk will provide feed in autumn/winter after a two year establishment period. *Allocasuarina obesa* (also called *A. glauca*) had 44% digestibility and 12% protein when subjected tothe same tests.

Light to thick barley grass

A much wider range of fodder shrubs is available for these areas, the best known being the saltbushes and blue bush. These are often planted as a dense stand of shrubs on a 3 m x 2 m pattern (3 m between rows, 2 m between plants withinrows). At this density, trials by the Department of Agriculture have indicated returns of $65 per hectare per year from a grazing period restricted to 6 to 8 weeks over Autumn/Early Winter, with stocking rates of around 20 sheep per hectare over that period. Combining these valuable fodder plants with less digestible taller shrubs at a wider spacing of about 5 metres between rows may lower overall production but adds greater wind protection, may increase water use and give better long term

protection against pests and diseases of pasture and stock. All the plants shown in this category can be direct seeded using the niche technique achieved by the Mallen Seeder® and Kimberley Seeds Kimseed Contour Niche Seeder®.

A total seeding rate of between 1 kg and 2 kg per hectare of mixed seed should be used mixed with No. 4 grade vermiculite as a mulch. An estimated 4000 ha of saltbush was planted using this technique last year (1988).

Wavy Leaf Saltbush	1 kg
"Rivermoor" Saltbush	500 g
Blue Bush	500 g
Acacias	250 g
Allocasuarinas	50 g

Suggested seed mix per hectare

Table 8

Cost:	Fencing	$125-$150/ha
	Contract seeding (rows)	$100-$200/ha
	Inter row	$50/ha

3. *Deep Sands*

The most effective long term method of controlling dry land salinity and waterlogging is interception and use of water on the higher slopes of the catchment. The deeper the soil the more options occur and for the deep well drained sands the options include:

- fodder trees and shrubs
- perennial pastures
- agroforestry; combinations of trees for shade and shelter with pasture or crop rotations.

Fodder Trees and Shrubs

The most widespread of these in Western Australia is the legume Tagasaste (Chamaecytisus palmensis) with an estimated 6000 ha planted in 1988. It grows vigorously on deep infertile sands producing 3 tonnes per hectare per year of edible dry matter on 500 mm annual rainfall (Oldham and Mattinson, 1988). Protein content of leaf material is 20% with about 60% digestibility. The only data available from deep infertile sands comes from New Norcia where the summer rain (October to May) makes up only 17% of the total. On this area of the south coast where summer rainfall makes up to 30% of the annual total, production could well be higher.

In terms of stocking rates, this production is equivalent to 3000 grazing days per hectare per year, achieved at 30 sheep per hectare for 100 days over the summer/autumn period and spelling for the rest of the year. Used in this way tagasaste has proven to be a substitute for hand feeding and shown up to 30% increase in wool productionfrom weaners when compared to flockmates on annual pastur plus lupins. Tagasaste has also shown a smaller increase in micron with the extra wool production than supplementary feeds.

Establishment of pure stands aims at producing a density of 1000 trees per hectare with trees 2 metres apart in hedgerows 5 metres apart. The most common establishment method is direct seeding at 300 to 500 gm per hectare of inoculated seed using a precision seeder. This 'scalps' a 1 metre width of topsoil, removing weeds and weed seed and drops a group of 6 to 8 seeds every half metre of row. The seeds are covered with a press-wheel and in non-wetting sands, a wetting agent spray. Leaving the 5 metre interrow undisturbed provides protection against wind erosion.

Plantations have also been established using a combine . Tagasaste can be planted through the middle row(s) with three rows either side blocked off to limit competition and a cover crop of oats or lupins sown through the remaining rows. Trailed presswheels or culti-packer will improve germination. Harvesting of the cover crop will not damage the tagasaste as cutting at that age will promote a well branched bushy shrub.

The major problem with establishment is insect damage within the first few weeks of emergence. Red legged earth mite and cutworm in particular have wiped out plantings within the first few days of emergence. Plantations need to be watched closely from 14 to 21 days after sowing and sprayed if necessary.

Tagasaste has the disadvantage of requiring cutting once a year prior to first grazing to achieve the production results mentioned earlier. This costs about $20 per hectare per year, based on a rate of 10 hectares per day with a reinforced

pasture mower set at 1 m above ground level.

To reduce the risk of complete wipeout of stands by insect pests (as happened with Hunter River Lucerne in the 1970s) a mixed planting of fodder shrubs is recommended. The Acacias in general have high protein contents (around 15%) but are relatively indigestible (30%) due to the high lignin content. They are grazed by sheep if presented with a mixture of dry roughage and more palatable shrubs.

The perennial lupin mentioned in Table 9 is similarly eaten in a mixed stand despite high alkaloid levels. Selection of lines with lower alkaloids would make this plant more useful. Little is known of the tree medic at this stage other than that it appears slow growing and may be drought tolerant.

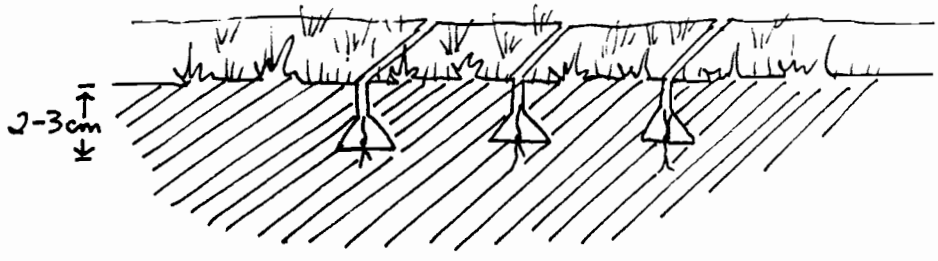
Chamaecytisus palmensis (Tagasaste)	300 g
Acacia saligna (Coast wattle) }	
A. Cyclops (Wattle) }	50 g
Lupinus arborea (Tree Lupin)	50 g
Medicago arborea (Tree medic)	trial

Fodder Shrub Mix (g/ha)
Table 9

Perennial Pastures

Stands of perennial pastures up to twenty years old can be found along the south coast grazed by both sheep and cattle. Unfortunately little information exists on production compared with annual pastures, and many stands established initially for cattle have since been grazed out due to continuous stocking with sheep.

The biggest risk in establishing perennial pastures on deep sands is wind erosion. The need to achieve good weed control usually means two broadacre application of Sprayseed® or Roundup® which leaves sowing late (June-July). Non wetting sands common with old annual pasture stands often make germination difficult and warrant the use of a cultipacker or presswheels. A technique used successfully in New Zealand and the Eastern States of Australia is the Baker Boot illustrated below. The principle is to disturb the surface as little as possible and create a cavity at a depth of 2-3 cm. This cavity creates a high humidity environment very suitable for the germination of pasture seed. This method is used for renovating existing pastures as well as establishment and is also referred to as the 'inverted T-tyne' (Schroeder 1989).



Perennial Pasture Seeding — The Baker Boot Principle
Fig. 5

Another way to limit the risk of wind erosion is to plant perennial pastures between established stands of fodder shrubs or wind breaks of taller trees.

Research into the effects of windbreaks on pasture and animal production is being carried out from the Esperance office of CALM. Early indications are that the effect of a windbreak can be seen 15 times the height of the windbreak downwind (Bicknell 1989). How this reflects on pasture and animal performance is yet to be established. Work by Chinese foresters suggested improvement in crop yields of 20% with the use of a network of windbreaks about 10 m high and 200 m apart. In their experience windbreaks are effective about 20 times their height downwind.

Grasses	'Mission' Veldt Grass (Eroharta calycina) 'Consol' Love Grass (Erograstis sp.) 'Pioneer' Rhodes Grass (Chloris gayana)	1-2 kg/ha
Legumes	'Hunterfield' Lucerne (Medicago sativa) 'Sheffield' Lucerne 'WL 516' Lucerne	2-3 kg/ha
Herbs	Evening Primrose (Oenothera caespitosa)	1 kg/ha

Perennial Pasture Mix for Deep Sands
Table 10

Evening Primrose is a common herb of roadsides and will persist in deep infertile sands in areas with a rainfall down to 300mm. It has been used to control sand drift together with cereal rye and is a useful early coloniser of such areas. It is readily eaten by sheep but is apparently not well liked by rabbits. It was used in combination with veldt grass on sands in the Mallee and Eyre Peninsula of South Australia before the introduction of Hunter River lucerne and has replaced some of those stands recently.

Mixtures of species are recommended for all pasture sowings not only for better protection of the sward from insect and pest attack but also to minimise toxicity to stock. Some of these species can cause nitrate poisoning after periods of high rainfall and low sunlight (as can Capeweed) when dominant in a pasture. Phalaris (Table 12) has also been known to cause alkaloid poisoning when in pure stands (Buchanan, 1989).

All of these pasture species require rotational grazing and spelling in spring to allow seeding. Their summer-autumn response to rain complements sub-clover pastures on other soils. Subterranean clovers and serradellas included in this mix will boost winter-spring production. Insect control soon after emergence is often necessary for these pastures particularly for cutworm and red-legged earth mite.

Cost:	Weed control	$20
	Seed	$40-60
	Insect control	$10-20
	Total	$70-$100/ha

Agroforestry

As mentioned in the previous section, both cropping and establishment of perennial pasture are high risk activities on these soils. One way to reduce that risk is to establish tree belts at intervals across paddocks of deep sand on a north-south axis that will limit the impact of westerly and easterly winds and limit crop and pasture shading.

Several farmers in the Esperance region have established windbreaks on this pattern with tree belts 20 to 30 metres wide at intervals about 200 metres across paddocks (Gary and Jan English, Mike and Tony Overheu).

Tall	*Eucalyptus*	*gomphocephela* (Tuart)
		leucoxylon (Yellow gum)
		occidentalis (Swamp yate)
		botryoides (Southern mahogany)
		grandis (Rose gum)
		globulus (Tasmanian blue gum)
	Pinus	*radiata* (Monterey pine)
Medium	*Acacia*	*saligna* (Coast wattle
		cyclops
	Albizia	*lophantha* (Cape wattle)
	Hakea	*laurina* (Pincushion hakea)
	Eucalyptus	*platypus* var heterophylla (Coastal Moort)
		tetragona (Blue mallee)
		falcata (Mallee)
		decipiens (Mallee)
		lansdowneana (Port Lincoln Mallee)
		eremophila (Tall sand mallee)
		spathulata (Swamp mallet)
	Chamaecytisus palmensis (Tagasaste)	
	Agonis	*flexuosa* (Peppermint)
Short	*Leptospermum laevigatum* (Tea-tree)	
	Melaleuca	*armillaris* (Bracelet honey myrtle)
		ericafolia
		nesophila (Western tea myrtle)
		hamulosa
	Callistemon	*phoenicius* (Lesser bottlebrush)
	Calothamnus	*quadrifidus* (One-sided bottlebrush)
	Pennisetum	*purpurea* (Elephant grass)

Trees for Shade and Shelter on Deep Sands
Table 11

Taking as an example a paddock 1km x 1 km (100 ha) to establish 3-row tree belts at 200 metre intervals would require 10 km of fencing, (4 double fenced, 2 single fenced).

Trees required would be 3600 in total (6 windbreaks of 3 rows each gives 18 km of row with 200 trees per kilometre at 5 metre spacings).

The cost for tree planting alone would be $2700 - $3600 or $27 to $36/ha. Fencing would be an additional $5000 or $50/ha, however fencing costs could be reduced by using a cereal/legume crop rotation in this paddock until the trees were established and staggering the fencing over several years. Fencing would be necessary eventually to control stock access to windbreaks to prevent over grazing of the under storey.

The trees in Table 11 can all be planted from seed or seedlings with the exception of Elephant Grass which is a dense tussock to 3 m and can be planted as unrooted cuttings.

A good layout for a windbreak is three rows per belt, rows 5 to 7 metres apart with tall species in the centre and medium and short species on the outer rows, trees within rows spaced 5 metres apart.

Elephant grass could also be used to establish windbreaks in its own right if planted in rows at 30 to 40 metre intervals unfenced. It has proven to be very drought tolerant and the new growth is readily eaten by stock.

Protected in this way, areas of deep sand can be suited to a lupin/wheat rotation using direct drilling. Alternatively perennial pastures can be established as described in the previous section.

Costs: 3 row shelter belts at 200 m intervals across 1 km x 1 km paddock:

fencing	$50/ha;
trees	$27-36/ha
Cereal/legume crop rotation:	no extra cost
Perennial pastures:	$70-100/ha
(3 row shelter belts direct seeded:	$10/ha)

4. Low lying, poorly drained, non saline

These areas are usually the most at risk of becoming saline and are often characterised by small scale depressions or gilgai. The earliest signs of salinity often occur in these depressions.

- On a broadacre basis the best strategy for these soils is a perennial pasture mix that is less drought tolerant than that recommended for deep sands.
- On a small scale, localised areas of waterlogging are well suited to deciduous fodder trees.
- Trees for shade and shelter suited to these soils are recommended in Table 14.

Perennial pastures

In addition to the species given in Table 10, the following are suitable to the wetter low lying areas. Establishment is the same as for those in Table 10.

Grasses	Perennial ryegrass (*Lolium perenne*)
	varieties 'Brumby'
	'Kangaroo Valley'
	'Victorian'
	'Sirolan' Phalaris (*Phalaris aquatica*)
	'Sirosa' Phalaris (*Phalaris aquatica)*
	'Demeter' Fescue (*Festuca arundinacea*)
	'Porto' Cocksfoot (*Dactylis glomerata*)
	Paspalum (*Paspalum dilatatum*)
Legumes	Balansa clover (*Trifolium balansa* var 'Paradana')
	Strawberry clover (*Trifolium fragiferum* var 'Palestine')
	'Haifa' clover (*Trifolium repens*)

Perennial Pasture Mix for Low Lying Areas
Table 12

Cost: $70-$100/ha

Fodder Trees for Low Lying Areas

Relatively new to the south coast are deciduous fodder trees that will tolerate waterlogging but have little tolerance to salt (Table 13). As they lose their leaves over winter and remain dormant, the willows in particular can tolerate periods of several weeks partly submerged. Their period of most active growth is spring and summer when they transpire water rapidly. Several of the willow and poplar varieties have been selected for their feed value and have between 12% and 14% protein in the leaf material which has high digestibility in the order of 70%.

Very little is known about grazing management or production from these trees and they are recommended on a trial basis. The willows are best planted at a similar spacing to tagasaste at 2 metres between plants in rows 5 metres apart. They require cutting for the bulk of their leaf material to remain within the reach of grazing stock. They can be planted as bare rooted trees or cuttings which can be taken in winter prior to planting.

The White Poplar will sucker readily and widely spaced trees (at least 7 m x 7 m) will produce a highly palatable under storey each spring/summer once they approach adult size (maybe 5 to 7 years). Grazing of these would be less labour intensive than maintaining hedgerows as with willows or tagasaste. Poplars are best grown as bare rooted trees, at least 12 months old although they can be grown from cuttings in the manner described for Tamarisks. The variety 65/31 appears to be the most promising on the south coast.

		variety
Willows		
	Salix matsudana x *salix alba* (hybrid willow)	1001
		1002
Poplars	*Populus alba* (White poplar)*	
	Populus x *euramericana* (Hybrid cottonwood)	I488
	Populus x *deltoides*	65/31
	Populus sp. 'Euphrates'*	

Deciduous Trees with Fodder Potential for Wetter Areas
Table 13

* reported to have tolerance to mild salinity

Cost: bare rooted trees $100-$200 per hundred

Trees for Shade and Shelter in Low Lying Areas

The following trees would have greatest application in re-vegetating drainage lines and waterways. They would be best established as seedlings on raised mounds to limit exposure to waterlogging in the first season.

Eucalyptus	*occidentalis* (Swamp yate)
	spathulata (Swamp mallet)
	rudis (Flooded gum)
	famelica (Green salt mallee)
Melaleuca	*cuticularis* (White paperbark)
	brevifolia
	hamulosa
	acuminata
Allocasuarina obesa (She-oak)	
Salix alba x	*matsudana* (Hybrid willow)

Trees for Shade and Shelter on Low Lying Sites
Table 14

Cost: 3-row tree belts - as seedlings $360/km
direct seeding$15/km

(2 combine widths or 3 rows contract seeding)

5. *Level Duplex Soils (> 30 cm)*

This group takes in some of the better cropping soils in the catchment, but being shallow they do not lend themselves to the highest potential yield and water use cropping pattern of cereal/lupin rotation. A greater potential improvement in water use for these soils would come from:

- improved plant nutrition
- perennial pastures
- agroforestry.

Fertiliser

Cereal crops on these soils use somewhere between 80 and 95% of the rain that falls during the crops' growing season, but as little as 60% of the total rainfall over a full twelve month season.

A greater potential water use from these soils would come directly from increased crop and pasture growth through increased fertiliser use. The present average application of superphosphate in the catchment is 116 kg/ha per year, ranging from zero to 175 kg/ha. Apart from phosphate, low levels of copper, zinc and manganese may well be limiting production on these soils. A survey of plant samples submitted to CSBP for analysis in 1984 showed manganese and zinc deficiency were high in samples submitted from the Esperance and Ravensthorpe shires; 41% of samples showed zinc deficiency, 26% manganese deficiency and 18% copper deficiency.

Perennial pastures

A greater potential water use from these soils could also come from establishment of perennial pastures. Rainfall in the southern half of the catchment would favour those in Table 12, while the more drought tolerant species in Table 10 would be better suited to the northern half of the catchment.

These pastures are not ideally suited to shallow sand over gravel soils, however, and the highest return in terms of dollars per hectare would probably still come from annual pastures and cereal cropping, even though these continue to contribute to ground water recharge.

Fodder trees and shrubs will grow well on these soils provided they are deep ripped but in most cases this is physically difficult and financially prohibitive.

Careful site selection within this soil group may well produce suitable areas for perennial pastures and fodder shrubs.

Increased crop and pasture performance is likely using the agroforestry layout suggested in Section 3. Tree and shrub species for shallow soils are given in Table 15.

Eucalyptus	*occidentalis* (Swamp yate)
	botryoides (Southern mahogany)
	megacornuta (Warty yate)
	gardneri (Blue mallet)
	spathulata (Swamp mallet)
	conferuminata (Bald Island marlock)
Acacia	*cyclops*
	pycnantha
Hakea	*multilineata*
Melealeuca	*armillaris* (Bracelet honey myrtle)
	nesophila (Western tea myrtle)
Allocasuarina	*huegeliana* (Rock oak)
Calothamnus	*quadrifidus* (One sided bottlebrush)

Trees and Shrubs for Shade and Shelter on Shallow (Gravelly) Soils
Table 15

6. *Sloping Shallow Duplex Soils*

Options for this group include:

- water harvesting;
- improved plant nutrition
- limited perennial pastures
- agroforestry.

The greatest potential for increasing water interception and use on these soils is through physical water harvesting.Catchments for most key dams are located on these soils. Any earthworks that can be shown to intercept water that would otherwise contribute to soil degradation downslope is eligible to a 100% taxation deduction in the year of expenditure and would contribute to drought proofing a property at the same time.

Some of the better subterranean clover production is from these soils, and given that peak production is late winter/spring, this complements the production potential of perennial pastures and shrubs over the summer autumn and early winter period.

Some areas that fit into this category do carry perennial pastures, but as the moisture holding capacity of these soils is low they tend to be the more drought tolerant ones from Table 10, namely veldt grass and love grass.

Trees and shrubs for windbreaks on these soils are shown in Table 15.

Cost:	Perennial pasture	$70 - $100/ha
	3 row tree belts seedlings	$450 - $600/km
	Direct seed	$150 - $180/km
	(3 single rows or 2 combine widths)	

7. *Medium Duplex Soils (30 - 80 cm sand)*

On these soils there is the greatest potential for increasing water use in the catchment due to the area this group represents and its suitability to perennial pastures and crop rotation. Table 16 gives some indication of this potential showing water use by wheat and lucerne grown in adjacent paddocks on a sandy surfaced duplex soil at Gairdner. The wheat yielded 2.4 t/ha and the total grazing for the year from the lucerne was equivalent to a set stocking rate of 4.8 DSE/ha.

	Paddock 1 Wheat	Paddock 2 Lucerne
Rainfall		
May to November	241 mm	241 mm
Water use		
May to November	231 mm	155 mm
Seasonal recharge	+ 10 mm	+ 86 mm
Total rainfall		
November to November	384 mm	384 mm
Total water use		
November to November	231 mm	433 mm
Total recharge	+153 mm	-49 mm

Comparison of Water Use by Wheat and Lucerne
(from Nulsen and Baxter, 1986)
Table 16

Species selection for perennial pasture sowing on these soils would be a mixture of those given in Tables 10 and 12 with those in Table 12 being better suited to the southern half of the catchment and those in Table 10 the northern half.

Tree selection for general windbreaks and agroforestry would similarly be a mixture of those in Tables 11 and 15. Details of perennial pasture establishment and shelter belt planting are given in Section 3.

8. *Where to See Them*

A guide to sites where the tree and pastures species mentioned can be seen.

- *Eucalyptus famelica* (Green Salt Mallee) John and Pat McDougalls, 300 m south of Middle Road on location 793.
- *Melaleuca cuticularis* (White paperbark) *M. brevifolia* (Saltwater paperbark) Any saltwater lakes or swamps in the catchment, e.g. Masons Bay Road half way between Springdale Road and Middle Road.
- *Eucalyptus botryoides* (Southern mahogany) On Wally and Jen Clarkes', location 821, plus other windbreak species on shallow sand over gravel.
- *Most of the Eucalypts, Acacias, Melaleucas, Allocasuarinas and Callistemon* mentioned can be seen at the 'Gnamma' Arboretum 4 km west of Fence Road on the South Coast Highway on Bob Warren's.
- *Trees as salt water pumps* on Ray Walter's Property, 5 km east of Brookton on the Brookton Highway.
- *Direct seeded windbreaks* on Rod and Winston Crane's properties, locations 779 and 800 (4 years old) and Ron Fletcher's location 839 (20 years old).
- *Tagasaste* sown by combine, Winston Crane's location 800; sown by single row seeder, John and Pat McDougall's location 792.
- *Tree lupin* Bev Hundley's 'Green Scene' Nursery, (see suppliers)
- *Hybrid willow* John and Pat McDougall's location 792
- *Perennial Pastures* Rob Purvis' location 798 (cattle); Ian Upton's location 840 (sheep); recent establishment Jan and Garry English, Esperance.
- *Agroforestry* Ralph Silburn, Munglinup; Jan and Garry English and Mike and Tony Overheu, Esperance.
- *Elephant Grass* 'Gnamma' Arboretum, 4 km west of Fence Road on South Coast Highway and John Luberda's on the highway west of of Dalyup River.
- *Poplars* Bev Hundley, Green Scene Nursery, (see suppliers); Small Tree Farm Nursery (see suppliers).

Suppliers

All Forest Tree Services Pty. Ltd.,
Suite 5, 8 Clive Street West Perth
(09) 321 5386
- Contract tree planting

Chatfields Tree Nursery, Dennis and Jos Chatfield
PO Box 3 Tammin 6409
(096) 37 1075
- Seeds
- Farm Trees and shrubs (including Tagasaste and salt bush)
- Contract planting
- "Chatfield Tree Planter" for seedlings and direct planting

John Cook
PO Box 25 Dandaragan 6507
(096) 52 8062
- Tagasaste seed
- Planting and cutting machinery for fodder shrubs

Conservation and Land Management Nursery
PO Box 100 Narrogin 6312
(098) 81 1113
- Farm trees and shrubs

W.C. Diamond & Co.
PO Maya 6614
(096) 64 2011
- Saltbush seed and seedlings
- Contract planting
- Planting machinery for saltland

Fitzgerald Nursery, Rob Smart
PO Box 134 Jerramungup
(098) 35 6033
- Farm trees and shrubs including tagasaste

Geelup Native Plants
PO Box 236 Bridgetown 6255
(097) 61 1163
- Farm trees and shrubs

Gidgegannup Nursery, John Corey
Toodyay Road Gidgegannup 6555
(095) 74 6163
- Farm trees and shrubs
- "Shelter belter" for tree planting

Green Scene Nursery, Bev and Mardon Hundley
'Wangalee Downs' RMB 7055 Esperance 6450
(090) 76 8519
- Seeds of perennial and annual pasture and fodder shrubs
- Cuttings and bare rooted trees: willows, poplars, elephant grass
- Trees and shrubs including tagasaste
- Contract seeding with "Baker Boot" seeder

Greening Australia (CALM office, Esperance) John Bray
PO Box 234 Esperance
(090) 71 3733
- Hire of tree planter

Greening Australia Hamel Nursery
PO Box 147 Waroona 6215
(097) 33 1241
- Farm trees and shrubs

Harvestaire Pty Ltd
18 Mumford Place Balcatta 6021
(09) 344 7433
- Cutting machinery for fodder shrubs

Jerramungup Land Conservation District Committee
PO Jerramungup
Secretary Bob Twigg (098) 35 4021
- Hire of planting machinery

Kimberley Seeds, Steve and Greg Hill
51 King Edward Road Osborne Park 6017
(09) 446 4377
- Seeds for pastures, fodder shrubs and farm trees
- Contract planting of fodder shrubs, saltbush and direct seeded trees
- Planting machinery

Greg Kleinig, Dalyup
PO 156 Esperance
(090) 76 5057
- Contract seeding of fodder shrubs

Mitchells Nursery
PO Box 47 Wickepin 6370
(098) 88 1066
- Farm trees and shrubs

Nindethana Seed Service, Peter Luscombe
RMB 939 Woogenilup 6324
(098) 54 1066
- Seeds of Australian native plants

Nufab, Peter Nunn
PO Box 171 Dongara
(099) 27 1297
- 3-point linkage tree planter
- Hand planting spear for seedlings

Ravensthorpe Land Conservation Committee
Secretary: Michael Palmer (098) 38 5030
PO Box 165 Ravensthorpe WA 6341
- Hire of tree planter in Ravensthorpe shire

Small Tree Farm, Andrew Thamo and Christine Sharp
PO Box 27 Balingup 6253
(097) 64 1113
- Farm trees and shrubs specialising in deciduous trees including poplar and willow

W.A. Chip and Pulp Co. (WACAP)
Eastbourne Road Manginup 6258
(097) 71 1222
- Eucalypt seedlings

Peter Walmsley
RMB 9257 Lower Denmark Road Albany
(098) 41 5786
- Farm trees and shrubs

Wendana Saltbush Nursery
PO Box 56 Gnowangerup 6335
(098) 27 1113
- Saltbush seedlings

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Tolerance	Salinity ppm TDS*	Plants
sensitive	500 - 1,500	lovegrass, cocksfoot phalaris, oats, wheat lucerne
Slightly Salt Tolerant	1,500 – 3,500	perennial rye, strawberry clover, barley, tall fescue, rhodes grass, tall wheat grass, *Eucalyptus botryoides, E. occidentalis, E. spathulata, E. kondininensis*
Salt Tolerant	3,500 – 13,000	*Puccinellia, E. sargentii, Melaleuca thyoides, Allocasuarina obesa, Tamarix spp*, salt bushes.

Salt Tolerance of Selected Plants
(in order of tolerance)
Table 17

* parts per million Total Dissolved Solids
1 ppm = 1 mg/L (milligram per litre)
Conductivity in micro Siemens per metre (mS/m) x 6·5 = 1 mg/L
1 grain per gallon = 14·3 mg/L or ppm

	Salinity ppm TDS
Human consumption	2,000
Lambs, weaners, breeding ewes	7,000
Beef cattle	10,000
Adult sheep	10,500 — 14,000

Water Quality for Human and Stock Consumption
Table 18

Contacts

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