Chapter 14 — Vegetation management

Vegetation can be planted (or retained) to manage water:

- by reducing recharge to the groundwater
- by intercepting water as it moves through the landscape
- by increasing the rate of groundwater discharge.

Vegetation in areas of the landscape

Careful planning is the key to cost-effective treatment of salinity. Approaches integrating vegetation with engineering works and modified farming practices are most likely to be successful.

It is generally better to focus vegetation management on transmission and recharge areas than discharge areas. This is because the high salt concentrations in the soil and groundwater in discharge areas, often accompanied by seasonal waterlogging and the presence of sodic soils, create unfavourable conditions for plant survival and growth. The effectiveness of increasing vegetative extraction of saline groundwater in the discharge area alone (without reducing recharge) is limited because:

- it is difficult to establish plants in saline environments
- the rate at which plants use water depends on the stress they experience
- the amount of water supplied by the comparatively extensive recharge area will usually be far in excess of the transpiration capacities of vegetation planted on the discharge area, even if all the vegetation were using water at the optimal rate
- special management of the area will be required for long-term stability
- the removal of water by transpiration may increase soil salinity levels and aggravate the problem of insufficient water use (Morris & Thompson 1983; Thorburn et al. 1986).

Vegetation in the discharge area is appropriate for managing erosion and maintaining some productivity. Unless the supply of water to the discharge area is reduced, a permanent reduction of the problem is not likely to be achieved by vegetation in the discharge area alone.

The information in the following sections on species selection applies generally to selecting pasture, crop and tree species for managing salinity in summer rainfall areas. Species to be planted in recharge, transmission or discharge areas that are adapted for the general site conditions will improve the likelihood of survival and growth without requiring excessive maintenance during periods when conditions are unfavourable.

Recharge areas

In recharge areas, trees and high water use crops can reduce deep drainage by using more water to a greater depth (creating higher antecedent soil water deficits, Morris and Thompson 1983) and by intercepting more rain in the canopy than most pastures or crops, especially in winter rainfall areas. In summer rainfall areas, summer fallow and heavily grazed pastures will result in increased recharge. Opportunity cropping and pasture systems which include some deeper rooted species will reduce recharge to some extent.

The soil water available to plants in recharge areas is not usually saline and thus the normal species selection factors for local site conditions will indicate the long-term growth of the chosen species. Ideally, species with high water use capability are preferred.

Factors to be considered in selecting species for recharge area plantings are:

- site conditions—rainfall, risk of frost, exposure to winds and sun, soil types, existing vegetation, original vegetation type
- species water use capability
- in the case of trees, multiple use considerations—possible use for timber production, stock shade or shelter, windbreaks, wildlife habitat, or tree products such as honey, bush tucker, flowers, oils or seed.

Figure 55. Recharge area plantings in a salt-affected catchment near Yass, New South Wales.

Transmission areas

Transmission area plantings can be an effective option when good quality groundwater is moving through the landscape in a zone accessible to plant roots. For instance, access by plant roots to the groundwater should not be impeded by structures such as hard pans or other geological formations.

If groundwater in the transmission area is saline, transmission area plantings may be ineffective. Water uptake is likely to decrease over time as salt becomes concentrated in the root zone, thus reducing the effectiveness of vegetation in removing groundwater. A rough calculation of catchment water balance is needed to see if the area planned for revegetation can use sufficient water. (Calculating catchment water balance is described in ***Catchment groundwater balance*** estimation page 70.)

Conditions in transmission areas are often similar to those in recharge areas, possibly with higher levels of groundwater salinity. In some cases, transmission areas can have more favourable conditions for vegetation establishment than recharge areas because of better groundwater supplies or better soils on lower slope positions.

Species should be chosen on the basis of high water consumption capacity and the ability to cope with moderately saline groundwater (if present) and saline soils (which may occur over time). Multiple uses of trees would be important secondary considerations. Consideration could be given to species that can be irrigated with low to moderate salinity groundwater supplied by groundwater pumping.

Discharge areas

As discussed previously, vegetating discharge areas effectively can be difficult. However, planting discharge areas with salt- or waterlogging-tolerant vegetation can be important when recharge areas are hard to identify, difficult to manage or revegetate sufficiently to control recharge, or unavailable for management (for instance, if the recharge area is on another property).

Discharge area plantings provide an opportunity for bringing an area of land back into productive use. Many landholders prefer to focus remedial vegetation activity on the unproductive salted sites rather than to place productive agricultural uplands under alternative vegetation.

Combined with other planting or engineering works, discharge area plantings may lower the watertable sufficiently to prevent further concentration of salt on the soil surface by evaporation and to allow leaching of surface salt by rainfall, enabling more productive use of the site. Naturally saline soils support a diversity of species, some of which are useful agronomically. If vegetation strategies are well planned and managed, saline soils can be productive.

Figure 56. Tall wheat grass and Rhodes grass in a discharge area on the Darling Downs, Queensland.

Factors to be considered when choosing species for planting on discharge sites, usually very harsh environments, are:

- adaptation to the general site conditions
- salinity tolerance
- sodicity tolerance
- tolerance to poor soil drainage or waterlogging
- frost tolerance
- water use capability
- potential for multiple use (in the case of trees).

These factors often occur in combination, and this usually has a compounding impact on vegetation, young plants in particular. A more restricted range of species is likely to be available and opportunities for multiple use will be limited as plants are unlikely to perform well under highly saline or waterlogged conditions.

General site conditions

Adaptation to climate, soils, aspect and other factors has to be considered more carefully when choosing plants for the adverse conditions of discharge areas than for areas with favourable growing conditions.

Figure 57. Tree planting on a scalded discharge area near Kingaroy, Queensland.

Salinity tolerance

Many plant species are unaffected by relatively low soil salt concentrations. Some species can withstand moderate or high salinity levels. Relatively few species are able to tolerate very high levels of salt. Even where a species can survive in saline conditions, growth rates and resistance to disease may be severely retarded.

If irrigation with groundwater is proposed, a species' ability to tolerate irrigation with saline water may also need to be considered.

Sodicity tolerance

Many saline sites are also sodic. Plant species vary in their ability to tolerate sodic soils. The major constraints to plant growth in sodic soils (Marcar et al. 1993) are:

- poor physical conditions and correspondingly poor soil aeration when wet
- nutritional imbalances including deficiencies of trace elements
- specific ion toxicity (such as sodium, chloride or possibly boron).

Tolerance of poor soil drainage or waterlogging

Species adapted for dealing with poor drainage or waterlogging will usually be more successful in discharge areas. Some species can tolerate seasonal waterlogging, sometimes for many months, but many species are highly intolerant of these conditions. Waterlogging usually reduces the ability of plants to tolerate saline conditions (Marcar et al. 1991), so species that can survive a combination of salinity and waterlogging are often required. If watertables are consistently high, trees may form very shallow root systems, making them susceptible to windfall.

Frost tolerance

Saline discharge areas usually occur in the lowest parts of the landscape, where there is poor drainage of the cold air. If frosts occur in the area, frost-hardy species may be required.

Water use

Water use capability is an important factor when selecting species for discharge areas. However, in harsh conditions this factor will be secondary to selecting species that can survive on the site. Tree spacing and management can be used to some extent to affect the amount of water use in a planted area. Water use is determined by species, climate and local environmental factors.

Multiple uses

The economics of saline site rehabilitation improve substantially if financial returns can be obtained from trees used in the rehabilitation process.

If suitable matches can be made between tree species, site conditions, products and services, and good integration can be achieved between agricultural enterprises and tree management systems on the property, a high economic return can be obtained from landscapes supporting a large percentage of tree cover. Trees may also contribute services to the farm in terms of wildlife habitat, shade and shelter for crops and stock, and aesthetic value.

General site treatment

Many pasture, crop and tree species are most sensitive to salinity at germination and during establishment. Even species able to grow in extreme levels of soil salinity, such as saltbush, normally germinate and establish only after rain has flushed salts from the soil surface. Soil preparation methods and activities that reduce surface salt levels and promote plant growth are therefore vital for successful establishment of plants in saline environments.

Vegetative cover

In almost all areas susceptible to salting, the vegetative cover of the soil surface needs to be maintained and the soil surface not laid bare by cultivation or overgrazing. Where salting is associated with a shallow watertable, removing vegetation from the soil will lead to the surface accumulation of salts. In areas susceptible to scalding, a bare soil surface will be vulnerable to erosion processes, soil loss and soil degradation.

Mulching is beneficial because it reduces concentration of salts at the soil surface and aids plant establishment.

Grazing and stock control

Grazing and pest animals must be controlled by fencing or low stocking rates for pasture or tree planting or regeneration to be successful. In many cases, grazing control alone on the affected area and margins is sufficient to allow salt-affected areas to revegetate successfully. Costs include the cost of fencing and loss of amenity of the fenced-off area. Benefits include preventing the spread of the salting problem and being able to use the area again to some extent after revegetation.

Water movement control

The areas to be reclaimed should be protected from runoff water. A diversion bank can be used to direct water to more stable areas. Planting is best carried out at the beginning of the wet season when watertable levels are lowest and early rains have flushed salt from the surface.

Mounding

If the soil water is saline, trees, crops and pastures planted on the tops of standard mounds can be affected by evaporative salt accumulation at the high point of the mound. This effect can be minimised by using mulch, constructing broad mounds, and setting the plants off the top of the mound. Seedlings planted in the trough of M-shaped mounds are less likely to be affected by salinity because salt will accumulate in the peaks to either side of the trough.

There is mixed evidence on the benefits of forming mounds some time prior to planting. In M-shaped mounds, water collecting in the trough of the mound may leach some salt from the soil. However, capillary action and evaporation from the increased bare area of soil may bring additional salt into the mound. In standard-shaped mounds constructed prior to planting, salt accumulation in the mound can be a problem if insufficient rain falls to leach salts. Soil leaching can be achieved without salt accumulation if the mounds are mulched.

Vegetation options

A number of factors need to be considered when deciding whether and where to use crops, pasture or trees to manage salinity:

- landholder's goals—importance of initial cost and final financial return, time available to manage
- individual area characteristics—water source, water quality, landscape feature to be planted, soil characteristics, soil salinity and sodicity levels
- individual species characteristics—salt tolerance, water use, rooting depth, time to establishment, likely productivity
- time frame before a response will be evident—interaction between climate (period of dominant rainfall) and time to establishment of species.

Pasture

The following situations are more suitable for pastures than cropping:

- low-value land
- strongly undulating country or steep slopes
- soils of moderate to high permeability
- where soil acidity is not a limiting problem
- where deep-rooted or perennial grasses are viable
- if grazing gives viable returns
- if grazing control can be effected
- when agroforestry is an option
- when climate and/or water resources favour pastures.

Crops

Few traditional crops can be grown on saline soils. High water use crops can play a role in recharge control. Situations most suited to using crops to manage salinity include:

- soils of moderate to high fertility and low salinity
- soils with good plant-available water capacity
- soils have moderate to high clay content
- soils have low to moderate hydraulic conductivity
- soil erosion can be controlled
- areas suitable for cultivation
- where opportunity cropping in wetter years is an option
- where cropping practices, including fallow practices, can be managed to minimise recharge.

Trees

Under favourable conditions, trees can extract large quantities of water from the soil by transpiration and can directly intercept and evaporate rainfall. Trees actively use water for a greater part of the year than most crops and pastures. When planted in recharge areas, trees use more water to a greater depth in the root zone than shallower rooted species, reducing deep drainage. When planted in transmission and discharge areas, some tree species can draw water directly from the groundwater. However, less than favourable conditions in discharge areas are not optimal for timber production. Trees may also contribute less directly to salinity control by:

- providing shade and shelter on discharge areas, and reducing surface evaporation rates and the rate of concentration of salt at the soil surface
- assisting to reduce the risk of wind and water erosion on scalded sites by acting as windbreaks, providing a litter mulch, reducing raindrop energy and binding the soil with root systems.

Situations most suited to using trees to manage salinity include:

- shallow soils over weathered and fractured rock
- deep sandy or permeable soils
- steep and broken country
- where timber processing industries are situated nearby
- when shade or windbreaks are needed
- when wildlife protection is desired
- if agroforestry is an option.

Pasture

A variety of palatable and nutritious forage plants can be established on saline soils provided appropriate species are selected and management regimes adopted. Pastures on saline areas are most valuable if crash-grazed followed by a long spell. This allows pastures to recover and the salt-affected area to be utilised as a gap feed.

Pasture species

Grasses useful for waterlogged and saline conditions in Queensland are listed in the appendix ***Pasture species for saline soils*** (page 133). The legumes *Medicago sativa* cv. *Sirosal*, *M. scutellata*, *M. truncalata*, *Macroptilium lathyroides*, *M. atropurpureum* and *Trifolium fragiferum* tolerate mild salinity but are usually more difficult to establish (Russell 1976; Fisher & Skerman 1986; Runciman 1986). With all of these species, local suitability must be assessed.

Forage shrubs such as saltbush can raise the feed value of mixed pastures on saline soils. Saltbush, bluebush and related plants have been considered a valuable stabilising component of grazing pastures in arid and semiarid areas of Australia for many years because of their ability to maintain green leaf through seasonal dry spells and droughts. Closer to the coast, these species are valuable for grazing during dry periods, as their protein levels are maintained when other feeds have hayed off. It is necessary to have alternative feeds available (crop stubble, grasses) to dilute the high salt content of the shrubs. Some species do not tolerate waterlogging. Species which are known to grow well on saline soils, be palatable to stock, and withstand grazing pressures are indicated in the table in the appendix Pasture species for saline soils (page 133).

Samphires and glassworts are valuable in areas where extreme salinity and regular waterlogging prevent the growth of other plants. The protein content of samphire is high, but intake is reduced by salt levels of about 20% dry weight of chloride. These species may improve soil conditions such that other, less-tolerant species can establish through them.

Pasture establishment and maintenance

Pasture cultivation

Shallow cultivation is normally sufficient to establish pasture species and grasses. Deep ripping and agroplough are only justified if significant yield improvement is obtained as a result. It is not always necessary to spray or burn existing weed species to allow desirable species to establish successfully. In most saline areas in Queensland, heavy grazing of the area prior to planting will be sufficient to reduce competition.

Pasture planting

Many of the grasses used on salt-affected soils in Queensland can only be established from rooted clumps or turf. A sprig planter can be used for planting grasses such as marine and saltwater couch. If planting by hand, a shallow hole should be dug into which the grass clumps are pressed.

For species to be introduced by seed, shallow cultivation of the soil surface to dilute salts through the top few centimetres of soil is generally sufficient for establishment. Pioneer Rhodes grass establishes well from seed on highly saline soils; more palatable species included in the seed mix may be able to establish after Pioneer Rhodes.

On flat ground, a conventional combine without harrows can be used to provide variety in the soil surface. A scarifier can be useful immediately prior to sowing on highly saline soils. Seed is spread on the surface. On steep slopes, where cultivation is not recommended because of the risk of erosion, direct drill seeding may be appropriate provided the seed is not buried too deep. If machinery access is not practical, for example on waterlogged sites, spreading seed by hand on the soil surface is sufficient.

Saltbushes can be established from either seed or nursery-raised seedlings. Success rates are much higher if seedlings are used, but costs also increase. Double ridge or M-shaped mounds (discussed in ***Mounding*** page 101) are advisable to flush salts from the root zone of the young seedling to reduce transplanting shock. Mounds are also recommended for spot placements of seed covered by a mulch such as hay or vermiculite. The Mallen niche seeder can be used for this purpose (Malcolm & Allen 1981).

Optimal plant spacing varies between species; spacing should allow for sufficient grass growth between the bushes to provide a balanced diet. River saltbush (*Atriplex amnicola*) is best planted at 1000 plants/ha, whereas grey saltbush (*Atriplex cinerea*) is best planted at 125 plants/ha. Saltbush productivity can be improved significantly by using an agroplough and a nitrogen fertiliser such as DAP (Barrett-Lennard 1993).

Samphires are best established from seed sown on the surface (Malcolm & Cooper 1974). Seed can be spread by harvesting plant shoots soon after seeding and spreading these pieces. Coastal pigface (Sesuvium portulacastrum) establishes well from plant pieces (Townson & Roberts 1992).

Fertilising

To improve the condition of low sodicity/high salinity soils, gypsum can be applied before cultivation at a rate of 5 to 7 t/ha. However, if high levels of soluble salts are also present, gypsum will have little effect. Gypsum is recommended for clay soils with low salinity. Early in the following growing season, the area should be top-dressed with complete fertiliser 4:4:1 of NPK at 125 kg/ha. Local extension advice will be available on general fertiliser use.

Mulching

Mulching normally promotes grass establishment in salt-affected areas. Hay, straw or manure can be used. Grass hay is normally more suitable than cereal hay as seeds of undesirable species in grass hay are less likely to survive under saline conditions.

Grazing control

Stock should be excluded for at least 12 months and up to two years after salt-tolerant species are planted. Such areas can be grazed subsequently for short periods of time. Saltland pastures are most valuable when used as a feed reserve when other pastures are in short supply and spelled for the remainder of the year.

Crops

In recharge and transmission areas, crop type and cropping systems should be selected to maximise water use and minimise fallow and dormant periods.

As with pastures (previous section), it is appropriate to limit discussion here to cropping on marginal and salt-affected soils. Choosing crop species for recharge and transmission areas will relate more to soils and climate that to salinity as such.

On marginal soils, cropping can be viable if appropriate species are selected and careful management is practised. Extensive breeding programs have been conducted in an attempt to raise the salt tolerance of many crop species, but results have been largely disappointing. This is because traditional food crops, other than beets and date palms, are not halophytic and thus have relatively low salt tolerance.

Crop species

The levels of soil salinity tolerated by a range of crops are listed in the table in the appendix ***Plant salt-tolerance data*** (page 124). Alternatively, this information can be obtained by using the SALFPREDICT component of the SALF software package (see page 142). Species selected to tolerate the highest expected levels of salinity will be likely to produce the best yields.

It is also important to recognise that salt tolerance varies with the growth stage of plants. Some species are more salt tolerant at germination and emergence than after establishment. Table 42 lists the relative salt tolerances of a number of species for emergence versus yield. The salinity values provided can be equated to salinity measurements at the planting depth in normal soils. While 50% yield and 50% emergence are used for comparative purposes, cropping is not economically viable at these levels of reduction.

Table 42. Relative salt tolerance of various crops at emergence and during growth to maturity (from Maas 1986). Used with kind permission of E.V. Mass.

Common name	Scientific name	50% emergence* ECse (dS/m)	50% yield ECse (dS/m)
Grain crops			
Barley	*Hordeum vulgare*	16–24	18
Corn	*Zea mays*	21–24	5.9
Cotton	*Gossypium*	15	17
Rice	*Oryza sativa*	18	3.6
Safflower	*Carthamus tinctorius*	12	14
Sorghum	*Sorghum bicolor*	13	15
Wheat	*Triticum aeativum*	14–16	13
Heavy vegetables			
Beet, red	*Beta vulgaris*	13.8	9.6
Onion	*Allium cepa*	5.6	4.3
Sugarbeet	*Beta vulgaris*	7.5	15
Pasture spedes			
Cowpea	*Vigna unguiculata*	16	9.1
Lucerne	*Medicago sativa*	8–13	8.9
Vegetables			
Bean	*Phaseolus vulgaris*	8	3.6
Cabbage	*Brassica oleracea capitata*	13	7.0
Lettuce	*Lactuca sativa*	11	5.2
Tomato	*Lycopersicon lycopersicum*	7.6	7.6

Crop establishment and maintenance

In saline areas, evaporative concentration of salt on the soil surface or in the upper root zone is the most likely cause of poor crop response. Maintaining any amount of stubble on the soil surface will help to reduce evaporation. Minimum tillage practices and seeding into previous crop residues can also help to reduce evaporation.

By planting into the trough of M-shaped ridges or into the side of single-humped ridges, plants can be separated from the ridge peaks, where maximum evaporative salt concentration occurs (see ***Mounding*** page 101). However, if these practices are necessary, it may be more economically viable to move from crops to pasture.

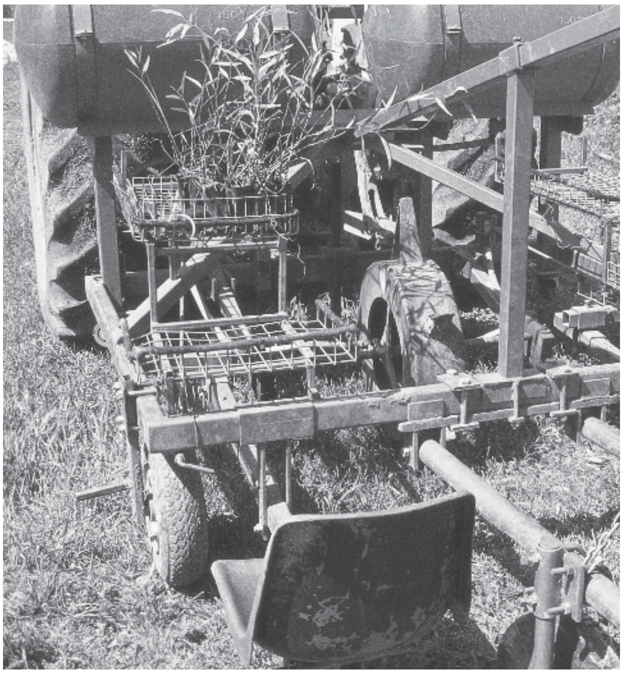
Periodic irrigation to flush salts from the soil surface can effectively reduce salt loads where soils are permeable and watertables are deeper than about 0.5 m.

Tree planting

Using trees to manage salinity is a long-term strategy. After trees are planted, it will be some years before watertable levels start to be affected and many years before the trees reach maturity and provide other desired benefits. The use of trees in salinity control should be consistent with property management aims and objectives and be integrated with other farm management activities so that the trees can be properly managed and maintained in the long term.

Trees can be used to enhance the farm environment, boost returns from established enterprises and provide opportunities for diversification into forestry or forest products.

Figure 58. An example of tree planting equipment utilised for large scale revegetation projects.



Shade and shelter produced by trees can improve growth rates in stock, increase calving and lambing percentages, extend the availability of pasture in times of drought or frost, and reduce soil-water consumption by crops (Bird et al. 1991; Daly 1984; Roberts 1984). Use of *Acacia* spp. on discharge sites or fodder species such as leucaena on recharge areas can provide high protein browse for stock, increasing productivity compared with pasture alone.

Many tree species produce valuable timber and wood products such as firewood, fencing timber, poles and sawlogs for structural or decorative purposes, veneer logs, and craft timbers. Many *Eucalyptus* and *Acacia* species suitable for salinity control are premium-quality structural and appearance-grade timbers. Some species of eucalyptus, tea tree and brush box are sought by beekeepers because of the excellent honey produced. Other tree products are fruits and nuts, oils, substances for medical use, flowers, bush tucker and seed. Mallee and *Melaleuca* species can be harvested for oil production. By selecting a diverse range of tree and shrub species for windbreaks and shade, a variety of food sources and nesting and shelter opportunities can be provided for native bird, mammal, reptile and invertebrate species.

Costs associated with tree planting generally include costs of tree establishment (fencing, site preparation) and maintenance, costs of lost agricultural production on the planted area, and cost of time spent away from other farming activities. Benefits of tree planting include returns to the landowner as well as to the community. Community benefits are in the form of reduced impact on downstream water quality, increased habitat values and improved salinity control on neighbouring properties.

Where trees are planted (or maintained) primarily to prevent or combat land degradation, such as to control salinity, stabilise erosion gullies, and establish windbreaks to prevent soil erosion, associated costs may have tax advantages. If trees are planted for the purpose of producing timber, associated costs are deductable as business-related expenses. Re-subdivision of the property according to land types is also deductible if it is carried out in accordance with an approved farm plan.

Appropriate reforestation layouts and attention to the choice of species can ensure that an optimal economic return is achieved. Comprehensive economic analysis of farm operations, comparing the status quo with strategic options, will allow the most economically efficient strategy to be selected. Computer-based models can facilitate this analysis. Department of Employment, Economic Development and Innovation officers are able to provide further information on costs and benefits to incorporate into analyses of growing trees for managing salinity. (Refer also to ***Decision support*** resources page 96.)

Tree species

Vegetation on the site and remnant native vegetation on similar sites in the area can indicate suitable species. However, if there have been extensive changes to the landscape (clearing, modification of soils by pasture improvement, cultivation or the addition of fertilisers), local species may no longer be the most suitable. (General information applicable to choosing tree species as well as pasture and crop species is covered in some detail in ***Vegetation in areas of the landscape*** page 98).

Species selection advice is available from Department of Environment and Resource Management (forestry) nurseries. The booklet *Trees and shrubs* (Queensland Forest Service 1991), a catalogue of plants available in departmental nurseries, provides comprehensive information on the characteristics and tolerances of a wide range of species. A computerised species selection system, the *Tree Selection Module*, is also accessible at departmental offices.

Table 43 is an abbreviated listing of tree species specifically recommended for discharge sites. A more comprehensive list, detailing salinity and waterlogging tolerances and suitability for multiple uses, is provided in the appendix ***Tree species for salinity management*** (page 137).

Table 43. Trees and shrubs recommended for planting on waterlogged and/or saline discharge sites in Queensland.

Common name	Scientific name	Suitable for sites that are		
		saline	water-logged	frost-prone
Trees				
Belah	*Casuarina cristata*	✓	✓	✓
River sheoak	*Casuarina cunninghamiana*	✓	✓	✓
Beach sheoak	*Casuarina equisetifolia*	✓	✓	✓
Swamp sheoak	*Casuarina glauca*	✓✓	✓✓	✓
Chinchilla white gum	*Eucalyptus argophloia*	✓	✗	✓
River red gum	*Eucalyptus camaldulensis*	✓✓	✓✓	✓
Tallowwood	*Eucalyptus microtheca*	✓	✗	✓
Grey box	*Eucalyptus molucanna*	✓	✗	✓
Swamp mahogany	*Eucalyptus robusta*	✓	✓	✗
Forest red gum	*Eucalyptus tereticornis*	✓	✓	✓
Broad-leaved tea tree	*Melaleuca leucadendra*	✓	✓✓	✗
Broad-leaved tea tree	*Melaleuca quinquenervia*	✓	✓✓	✓
Shrubs (<10 m)				
River cooba	*Acacia stenophylla*	✓	✗	✓
Tantoon	*Leptospermum polygalifolium*	✓	✓	✓
Leucaena	*Leucaena leucocephala*	✓	✗	✗
River tea tree	*Melaleuca bracteata*	✓	✓✓	✓
Totem poles	*Melaleuca decussata*	✓	✓	✗
Prickly-leaved paperbark	*Melaleuca nodosa*	✓	✓✓	✓
Thyme honeymyrtle	*Melaleuca thymifolia*	✓	✓	✓

Tree establishment and maintenance

Site planning

In most situations, a mixture of recharge, discharge and transmission area plantings will be required if trees are to be used in salinity control. Layout must be planned considering the hydrology and stratigraphy of the site, salinity, waterlogging, soil fertility and opportunities to integrate tree plantings with other property enterprises or to obtain products and benefits directly. The cost of fencing off young trees from stock (which is potentially considerable) can be reduced by integrating planting patterns with existing fencing layouts, if possible.

Options for **recharge** area plantings range from broad-scale revegetation of a significant proportion of the recharge area to intensive plantations of high water use trees on high recharge areas. Optimal performance will be obtained by planting trees at a density that allows each tree to develop a full canopy with a high leaf area index and an extensive root system. This suggests that wide-spaced agroforestry plantings may be very effective in grazing areas, while linear windbreaks may be appropriate in cropping and mixed farming areas. To bring the area back into agricultural production relatively quickly, trees can be planted densely to lower the watertable and later thinned to allow pasture to establish. Widely spaced large trees with well-developed root systems continue to use water at a high rate because of good air flow around the tree crowns.

The optimal amount of area for tree planting will vary from site to site, depending on local rainfall and aquifer characteristics. However, evidence from Western Australia indicates that replanting less than 15% of the recharge area is ineffective, and that effectiveness is directly proportional to the area planted. Increasing effects have been observed from planting larger proportions of cleared recharge areas, with the effect being proportional to the area of land replanted (Schofield 1991). However, this is likely to be highly variable depending on groundwater hydrology and rainfall characteristics and the results cannot be extrapolated to areas with different conditions.

In **transmission** areas where conditions are suitable, intensive plantations or belts of trees may be a cost-effective way of removing groundwater without using the large areas of land needed for recharge area plantings.

In **discharge** areas, tree planting is only appropriate where revegetation of a large enough area to use considerable amounts of groundwater relative to that flowing into the area can be achieved. In many cases this may mean using discharge area plantings in conjunction with other management strategies, such as engineering methods, to reduce groundwater recharge or to intercept water before it reaches the discharge area. The tendency of trees to concentrate salt in the root zone is likely to be a problem only in low rainfall areas where insufficient rain falls to periodically flush salt from the soil profile.

Site preparation

Under normal conditions, cultivation benefits young trees by improving root penetration and water infiltration and controlling weeds. However, on waterlogged sites, cultivation can exacerbate the waterlogging problem because heavy machinery compacts wet soil. On well-drained sites with clay subsoils, deep ripping can be useful to improve soil drainage and root penetration. The best time for deep ripping is winter or spring (as late as possible in the dry season) when the ground is least waterlogged and soils are at an optimal moisture content for penetration and shattering. Rip lines should be strip sprayed with a combination of knockdown and residual herbicides.

Gypsum can be added to improve soil permeability during tree establishment in areas with clay soils, poor soil drainage or waterlogging, or high pH or sodicity levels.

Mounding benefits tree survival and early tree growth on most saline and/or waterlogged sites. M-shaped mounds (with a small indentation along the top) are generally better for alleviating salinity problems, and standard (single-humped) mounds are better for waterlogging problems (see page 101). Surface drains (furrows) formed while creating mounds (see above) should be aligned to maximise surface water drainage from the site. (Drainage is discussed in Engineering methods page 110.)

Initial tree survival and early growth is likely to be improved if, prior to planting, salt can be leached from the soil (for instance, by using drip irrigation or plastic mulch on M-shaped mounds with holes punched for planting positions) without adding to waterlogging problems. Other methods of reducing topsoil salinity, such as mixing saline topsoil with less saline subsoil using deep cultivation, adding less saline soil to planting holes, or mixing organic matter with saline topsoil, appear to provide limited benefit and are not cost-effective.

Tree planting

On moderately saline sites with good drainage, the best time to plant is most likely after early summer rainfall has provided sufficient soil moisture. Planting at this time will maximise growth during the available growing season and provide shading and soil cover in the shortest possible time. In areas prone to seasonal waterlogging, planting should be carried out as soon as the area ceases to be waterlogged following the end of the wet season to allow the seedlings maximum time to become established before the next wet season. On severely salt-affected sites, the optimum time to plant may be after a period of high rainfall which will have flushed some salt from the soil surface and upper soil profile.

Survival can be improved by preconditioning seedlings to site conditions such as waterlogging and salinity. Gradual exposure to increasingly waterlogged conditions in the nursery appears to be the most effective part of this preconditioning.

Fertilising is generally recommended for tree planting projects, but good weed control is essential. At planting, 100 g of DAP or an equivalent N–P fertiliser may be applied to each seedling. However, as stressed trees growing on waterlogged or saline sites may be less able to utilise additional nutrients, fertiliser should generally only be added when trees are not suffering waterlogging or salinity stress.

Mulching improves tree survival, increases growth rates, improves soil moisture conditions and reduces salinity levels in the soil beneath mulch. The choice of mulch will usually depend on availability and cost. Effective material for mulch is sometimes available as a by-product of other farming activities.

Trees need to be watered well at the time of planting as for any planting project. Enhanced growth rates, improved productivity and more rapid lowering of watertables may be achieved if tree plantings can be irrigated with suitable quality groundwater.

Tree maintenance

Fencing to control animal access is critical on saline sites, both to prevent browsing damage by grazing stock or feral animals while trees are young and to control grazing of pastures on the site in the long term.

Trees stressed by growing in waterlogged or saline conditions are vulnerable to insect attack. The severity of insect attacks can be reduced in some instances by revegetating additional areas in the vicinity of the areas being treated for salinity. Insect pest problems will be minimised if a diverse range of native species is planted in an area to maximise the variety of habitats available.

Control of weeds (including grasses and pastures) around trees for a distance of about 1.5 m from the base of the tree for the first 12 to 18 months is generally necessary for good tree survival and growth. Weed control options include cultivation, hand weeding, mulching and the use of knockdown and residual herbicides.

Slashed or graded fire breaks 5 to 10 m wide should be maintained around planted areas. Slashing between rows of trees will minimise damage if fires do occur.

Tree retention

Retaining existing native vegetation plays an important role in limiting the occurrence or expansion of salting in salinity-prone catchments.

Land clearing in susceptible catchments should be undertaken only with extreme caution, and only after the costs, benefits and risks of the venture have been carefully considered. Small differences in deep drainage are all that is needed to alter the hydrological cycle sufficiently to result in salting or seepage problems. Long-term and very detailed studies would be required to detect such changes (Scanlan 1991).

There is little point in clearing marginally economic upland recharge areas if subsequent salinity in discharge areas takes fertile lowland areas out of production. Revegetation programs are considerably more costly than retaining the land in a naturally vegetated state. Planning for clearing in the context of a Property Management Plan will ensure that decisions will take into account all aspects of farm activities, including natural resources, finances, management implications and personal goals.

In some cases, stands of native vegetation can be used to generate a financial return in their own right. Managing stands of eucalyptus or cypress pine for commercial timber, farm timber or craft timber could provide a return at least equal to grazing if clearing, regeneration and land degradation costs are taken into account. Other enterprises based on remnant vegetation include opportunities for farm tourism, honey production and native food and seed collection (also discussed in Tree planting page 104).

Guidelines for retaining trees

General guidelines for retaining trees in areas susceptible to salinity to minimise the risk of salinity occurring or expanding are provided in Table 44 and the process for obtaining the necessary information to apply these guidelines is described in this section. At all times, decisions to retain or clear trees based on these guidelines need to be made in conjunction with all other tree retention/clearing guidelines, legislation and limitations. There are many reasons for retaining vegetation other than for salinity control, such as biodiversity, erosion control, aesthetics, wildlife habitat, net increase or decrease in productivity of the land and so on.

Table 44. Guidelines for retaining native vegetation, based on the results of local salinity investigations in Queensland.

Results of investigations in potential salinity indicator area	Level of salinity risk	Recommendation
Any current surface expression of salting	very high	Retain all trees in the indicator area, immediately downslope from the indicator area, and upslope from the indicator area to the top of the landform.

Any two of these high-risk indicators:
• vegetative indicators of wet or saline areas
• watertable depth less than 5 m below the surface
• evidence in the top 2 m of the soil profile of:
  • gleying
  • mottling
  • bands of $CaCO_3$ nodules (other than at the bottom of the root zone)
  • abundance of iron concretions or staining
  • abundance of manganese concretions or staining
• groundwater EC > 5 dS/m
• EM-31 reading > 150 mS/m
• evidence of periodic seepage
	high	Retain all trees in the potential discharge area, immediately downslope from the potential discharge area, and upslope from the potential discharge area to the top of the landform.

Any one of the high-risk indicators listed in the section above, or any of the following indicators: • EM-31 reading between 100 and 150 mS/m • incised drainage line < 2 m deep • any indicator approaching the level specified for the high-risk indicators listed in the section above	medium	Firstly, retain all trees in the potential discharge area. Secondly, investigate the salinity risk of the landform further to assess the extent to which trees should be retained in the area upslope from the potential discharge area to the top of the landform (in conjunction with other tree retention/clearing guidelines and limitations).
None of the indicators listed for high or medium risk	low	Plan tree retention/clearing decisions in conjunction with tree retention/clearing guidelines and limitations other than those for salinity risk. Note: Salinity may still occur in low-risk areas if subsequent changes in land use modify the hydrology of the catchment.

Firstly, all sites that may be currently salted or that appear to have potential for developing salinity need to be investigated. These sites will be apparent on the basis of:

- any evidence of salinity at the surface
- presence of vegetation communities or species which indicate saline or wet areas
- evidence of current or periodic seepages at the soil surface or in the soil profile
- depth to watertable of less than 5 m.

Investigations at these sites should include, as a minimum:

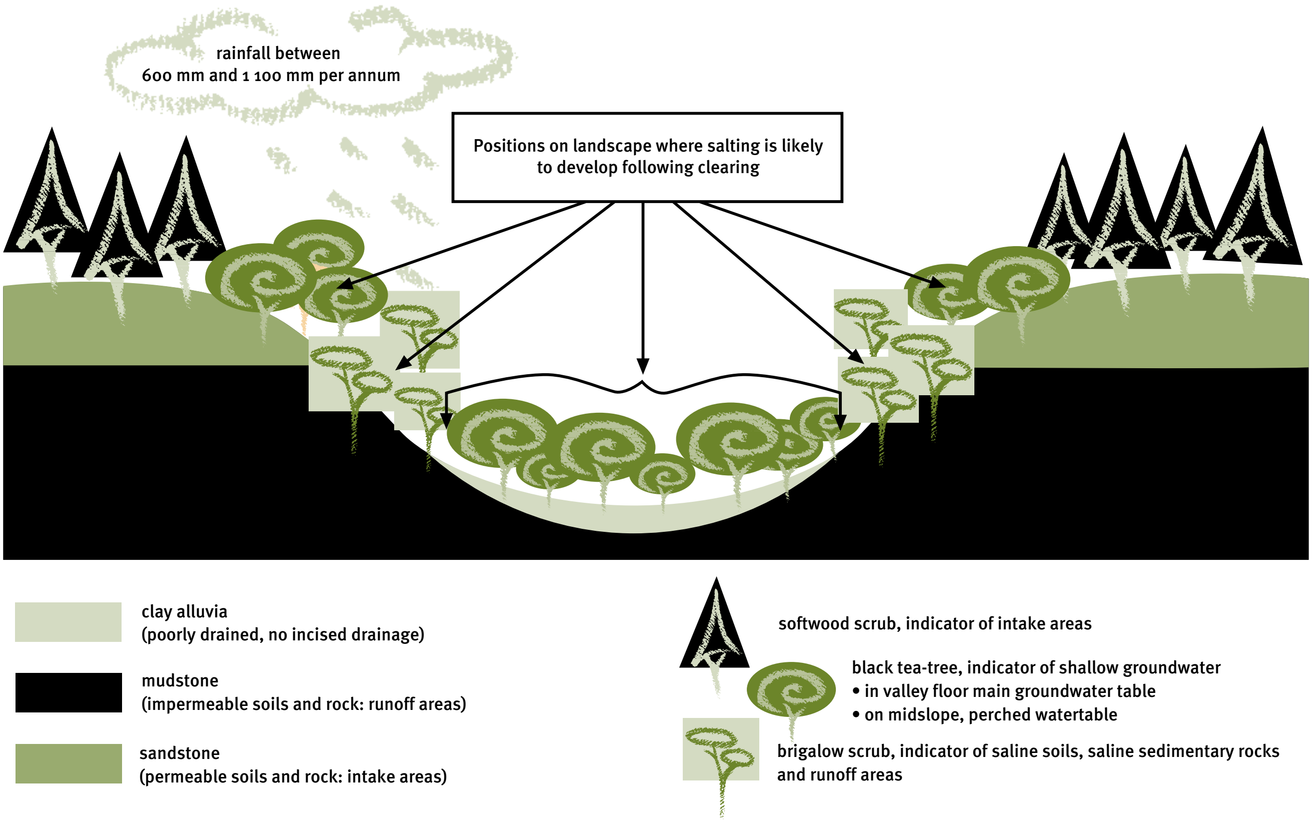
- salinity of the groundwater
- salinity of water in drainage lines nearby
- soil profile characteristics to a depth of 2 m or to the parent rock, in particular looking for gleying, $CaCO_3$ nodules, or iron or manganese concretions or staining
- if possible, an EM-31 survey over the area considered to be at risk.

Secondly, if these investigations indicate salinity, or if more comprehensive investigations are warranted on a catchment scale to identify areas with the potential to develop salinity, the search should be widened to include other areas in the catchment with similar characteristics to the sites already investigated, as well as the following areas:

- potential discharge sites of local landform types at risk of salinity
- low-lying and break-of-slope areas
- other suspect areas based on unusual soil or vegetation conditions, or areas that are prone to erosion.

Thirdly, the recommendations in Table 44 are guidelines for retaining trees based on the results of these site investigations. If no potential discharge sites occur in the catchment, salinity risk is likely to be low, and decisions for retaining or clearing trees should comply with tree retention/clearing guidelines and limitations other than those for salinity risk.

Figure 59. Strategic locations for retaining trees to minimise salinity occurrences or expansion in brigalow landscapes identified as being at risk of salinity.



Note, however, that areas that do not currently show evidence of salinity may become saline under changed land use.

Voller and Molloy (1993) provide a comprehensive checklist of points to consider when planning clearing operations in south Queensland. Guidelines in addition to those provided in Table 44 include:

- Retain a belt of trees at least 100 m wide on the toeslopes all around the catchment to help intercept increased groundwater flows and protect the valley flats from saline outbreaks.
- Retain trees along creek lines and geological contacts where permeable horizons overlie impermeable horizons.
- Retain trees along roadways and fence lines, scattered over pasture lands or incorporated into soil conservation measures in cropping lands.

Stock should be excluded from areas where vegetation has been cleared, at least periodically, to allow regeneration.

Strategic locations for retaining trees in landscapes which have been identified as having very high or high risk of salinity are illustrated in Figure 59.