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Reclaiming sandplain seeps by planting trees

By **Richard George**, Research Officer, Bunbury

Sandplain seeps affect large areas of agricultural land in Western Australia's eastern and northern wheatbelt and in the Great Southern.

These seeps are estimated to account for about 10 per cent of dryland salinity in the agricultural area.

Research and field observations show that seeps may be cheaply and quickly reclaimed using various types of drains or small blocks of trees (George 1990). This article discusses results of reclamation methods associated with tree planting on sandplain seeps in the eastern wheatbelt.

Causes of seeps

Sandplain seeps are caused by a shallow, perched aquifer which develops in deep sands. They are usually small, from one to 10 hectares. However, seeps are often the focal points for land degradation because they are prone to erosion and can cause waterlogging of larger areas downslope.

Sandplain seeps can cause groundwater recharge to the deep regional aquifer at depth. In some situations, the sandplain and deep aquifer systems combine, resulting in severe waterlogging and salinisation of the valley downstream.

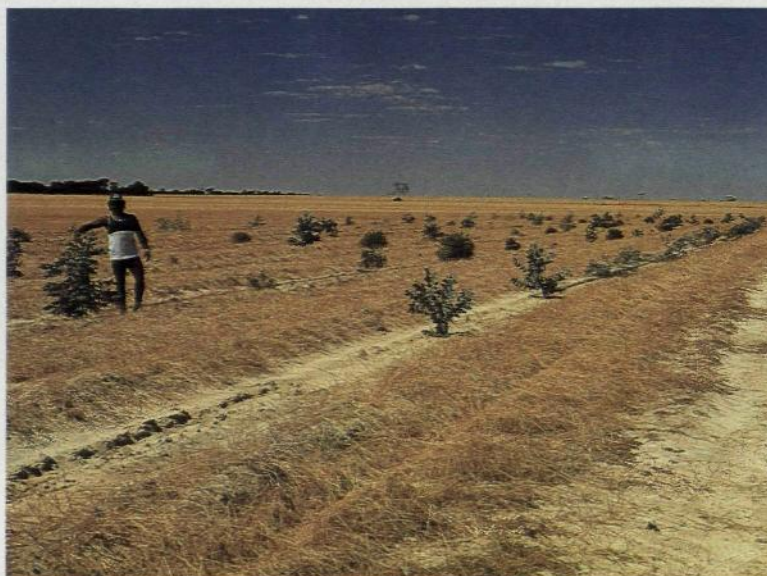
The primary cause of sandplain salinity is the clearing of the native mallee or 'wodjil' vegetation, which used more water than agricultural plants.

Rainfall, which moves beneath the annual crops and pastures, becomes groundwater as it percolates beyond the shallow root zone. The amount of water that becomes groundwater appears to be greatest under poor pastures and crops, and significantly lower beneath high yielding crops and pastures. This water accumulates on less permeable hardpans at the base of the deep sandy profiles (two to eight metres below the soil surface) and moves slowly (about 10 m per year) downhill.

As the hardpan comes closer to the soil surface further down the hillslope (usually less than one metre), the water-table is

exposed to evaporation and salts begin to concentrate to levels that are toxic to plants (Figure 1A). The perched aquifers which develop often only cover a small area of 10 to 20 ha above the seep and are usually only one to three metres deep.

The shallow aquifer consists of a thin veneer (two to eight metres) of the coarse textured surface soils which overly less permeable clays. The deep aquifer is based on the bedrock and consists of weathered materials which vary on thickness from only a few metres to more than 50 m.



*These young eucalypts were planted on the East Belka seep in June 1986, and this photo was taken in March 1987. *E. globulus* can be seen clearly, and remained the dominant species until 1989.*

Reclamation philosophy

CSIRO, the Water Authority of Western Australia and the Department of Conservation and Land Management (CALM) have measured the water-use of a wide variety of trees as part of a programme to overcome salinity problems. Some of the plantation strategies have been successful (Schofield *et al.*, 1989).

Similarly, research conducted by the Department of Agriculture has found that strategically placed plantations of trees, located near or on the discharge (saline) area, can lower water-tables, and reduce saline runoff and associated waterlogging (see Farmnotes 46/86 'Controlling saltland with trees' and 116/88 'Reclaiming sandplain seeps with small blocks of trees').

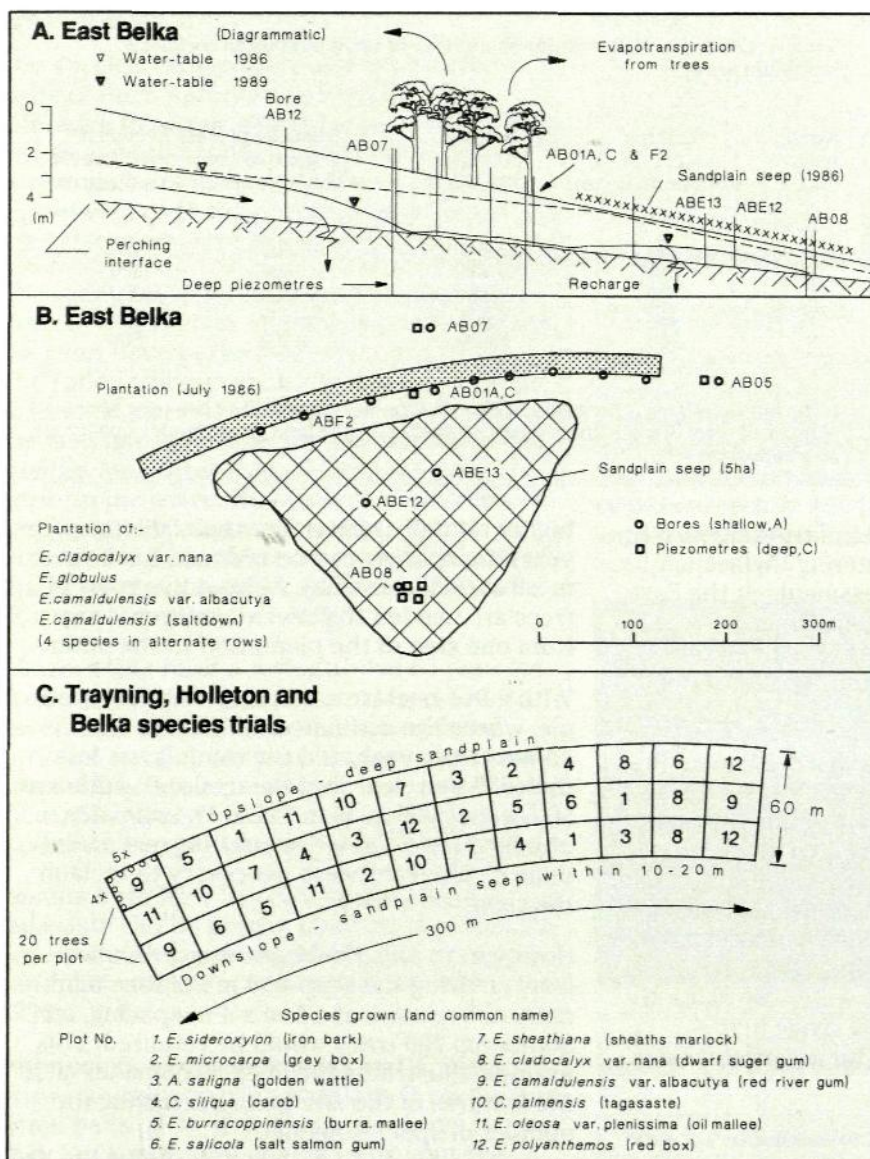


Figure 1. Diagrammatic section of the sandplain seep at East Belka (1A), the tree planting layout at this site (1B), and the location of tree species used in plantings at three sites (1C).



The sandplain seep, and tree plantings (just visible above the seep), at East Belka in July 1986. Note the two small mallee trees downslope from the seep in the main valley.

Experiments conducted to date have shown that young eucalypts are capable of withdrawing water from above and below the water-table, where groundwater salinity levels range from less than 180 milliSiemens per metre (about the water quality of Wellington Dam) to more than 1800 mS/m (a third as salty as sea water).

To determine whether small plantations could be used to reclaim sandplain seeps in the wheatbelt, the Department of Agriculture planted five trial sites with up to 15 species of eucalypts at East Belka in 1986, and in 1987 at Belka, Trayning, East Narembreen and Holleton (Figure 1A-C). A further three sites were investigated at Wyalkatchem, Mt Walker and Burakin where similar plantations had been established by interested farmers between the mid 1970s and early 1980s.

The aims of the research were to assess the trees' ability to grow, dry up the sandplain aquifer and prevent salt concentrating near the soil surface.

Water-use of trees

The volume of water that trees use depends on the species, their age, leaf area, access to water and nutrients, and on the quality of the groundwater. Experiments conducted on the water-use of trees suggest that some five-to-seven-year-old species of eucalypts use an average of 100 litres per day, per tree, during summer. The annual average water consumption of these trees ranged from 5,000 to 20,000 litres per year. This consumption is made up of soil moisture above and below the water-table. At present, little is known about the relative contribution from both reservoirs.

Table 1. Estimates of the minimum number of trees needed to reclaim a sandplain seep

Size of seep (ha)	Width of seep on upslope edge (m)	Volume of inflow (kL/year)	Number of trees needed if average tree groundwater use is	
			10 L/day/tree	30 L/day/tree
1	100	1,000	300	100
3	200	2,000	600	200
5	300	3,000	900	300
7	400	4,000	1,200	400
9	500	5,000	1,500	500

* The inflow volume is included as a guide. The age and width of the seep, the number of rows of trees, their density, water-use rates and groundwater quality are also important.

To determine the number of trees needed to prevent groundwater entering the seep, detailed hydrologic assessments at the East Belka site and drainage experiments at Doodlakine, Bencubbin and Holleton provided information on annual groundwater flows.

A simplified relationship was derived so that detailed hydrologic observations were not needed in the future to determine the minimum number of trees required at each new site. The approximate relationship that exists between seep size, width of the seep, volume of annual groundwater inflow and the number of trees required for reclamation is shown in Table 1. In the table, two water-use rates are used to indicate the likely range in the number of trees needed for a particular size of seep.

Plantation design

The nature of the site determines the number of trees needed to dry up a sandplain seep.

Several major requirements govern the size and location of the plantation. The plantation should be:

- wider than the upslope edge of the seep and
- contain enough trees to prevent groundwater being able to move through the plantation (Figure 1).

In most cases, the sandplain seeps investigated had an upslope width (along the contour) of between 100 and 500 m. In low rainfall areas (less than 350 mm per year) trees are spaced five metres apart along the contour and the row spacing is four metres. This spacing gives a density of 500 trees/ha. In

higher rainfall areas (more than 500 mm per year) the spacing can be reduced to about 4 m x 3 m (800 trees/ha). At least five rows of trees are needed to prevent water moving from one side of the plantation to the other.

With a five-hectare sandplain seep for example, where the estimated inflow was 3,000 kilolitres per year, and the rainfall was less than 350 mm/year, but the upslope width was 500 m (not 300 m as in Table 1), estimates obtained from Table 1 would suggest a minimum of 300 trees were necessary to reclaim the seep.

However, to effectively prevent groundwater from entering the seep and maintain a minimum of five rows at a 5 m x 4 m spacing, an additional 200 trees would be required. This example illustrates the need to consider all of the features of the site before selecting the number of species needed.

The maximum number of trees that need to be planted is flexible. The initial design was based on individual tree water-use rates of only 10 to 30 litres per day, though it has been shown that mature trees can use much more than this. The major constraint to plantation design is that a minimum of five to a maximum of ten rows of appropriate trees be planted immediately upslope from a seep, so that the tree belt can prevent water from moving downslope.

The tree belt should also form part of the farm plan. The plantation should be continued around on the contour as far as necessary, but with fewer rows of trees, say two to four rows. This will help prevent further seepages and provide shade and shelter for livestock, crops and pastures nearby.

Trees species

The species chosen were selected on the basis of their water-use, economic value, tolerance to salt or ability to grow on deep yellow sandplain soils. A summary of the performance of trees used in variety trials undertaken over the previous three years in the eastern wheatbelt is shown in Table 2.

The rating (as a percentage of those trees that survived) gives an indication of how well the trees have performed over this period. The rating value at each site is an average for at least 60 trees of each species grown. Over the next few years species' performance may change, and lower ranked trees may out-perform the currently highly ranked trees. At East Belka, for example, the *Eucalyptus camaldulensis* clone is now more highly rated than *E. cladocalyx* and *E. globulus*. The situation was the opposite in 1988

All trees that have a rating above 65 per cent are relatively fast growing and large, four to seven metres tall. Below this rating many varieties were either poorly adapted to local conditions (*Ceratonia siliqua* - poor establishment; *Chamaecytisus palmensis* - [tagasaste] susceptible to rabbits) or were slow growing.

Results from New Norcia suggest that if tagasaste can be grown, planting on about 80 per cent of the catchment will also dry up a sandplain seep (C. Oldham, pers. comm., 1990).

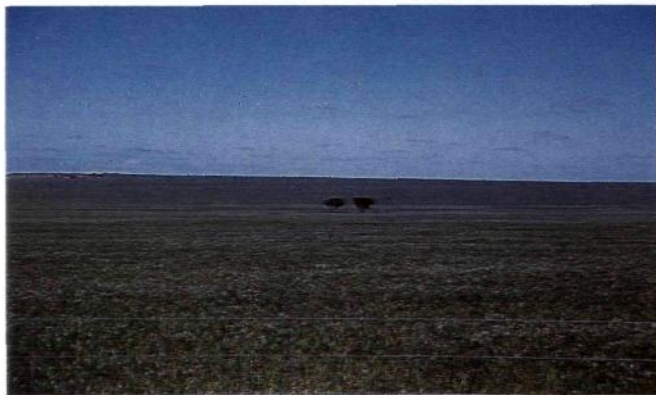
Although *E. burracoppinensis* and *E. oleosa* grow naturally on the sandplain, it seems that when belts of these trees occur above seeps, they are apparently unable to dry out the aquifer and the seeps remain and often kill the vegetation. We do not know why this happens. However, it could be these species are adapted to very low moisture and low salinity environments, are mature, have a lower stand density and are not able to cope with the new conditions induced by clearing

A range of species should be included in the plantation to account for changes in species adaption over time. Highly ranked species (1 to 5) could be planted over most of the site, while others (ranked 1 to 11) could also be included. Other species not investigated in this research programme (such as *E. loxophleba*, *E. kondininensis*, *E. occidentalis* or *E. sargentii*) which appear capable of a large water-use, could be included.

Understorey species, especially the acacias, could also be assessed as a part of a plantation. Species with known salt tolerance should be planted closest to the seep. All the other species should be planted in non-saline soils immediately upslope from the seep where less salt tolerance is required. However, if groundwaters beneath the plantation are saline, salt tolerant trees are preferred.

Effectiveness of trees

Groundwater monitoring wells have been installed throughout the experimental sites to monitor the effectiveness of the trees in lowering the water-table. Of the sites studied, only information from the East Belka catchment is presently adequate to assess the impact of the trees (planted June 1986) on the sandplain seep.



A view looking from the plantation, downslope across the reclaimed East Belka seep, towards the two small mallee trees visible in the photo on page 19. The wheat crop on the sandplain seep produced over 1 t/ha.

Table 2. Performance of 16 species of trees used to reclaim sandplain seeps

Botanical name	Common name	Rating (%)	Average dead	Rank
<i>Eucalyptus cladocalyx</i> var. nana	Dwarf sugar gum	92	9	1
<i>E. camaldulensis</i> **	River red gum, clone (saltdown)	90	6	2
<i>E. cladocalyx</i> *	Sugar gum	80	5	3
<i>E. globulus</i>	Tasmanian blue gum	80	3	3
<i>E. leptophylla</i> ,**				
now called <i>E. salicola</i>	Salt salmon gum	75	7	4
<i>E. camaldulensis</i> *	River red gum (albacutya)	75	9	4
<i>E. sheathiana</i>	Sheaths marlock	71	4	5
<i>Acacia saligna</i> **	Golden wattle	67	8	6
<i>E. sideroxylon</i>	Iron bark	65	1	7
<i>E. polyanthemus</i>	Red box	59	10	8
<i>E. burracoppinensis</i>	Burracoppin mallee	59	15	8
<i>E. camaldulensis</i> *	River red gum (wiluna)	56	19	9
<i>E. oleosa</i> (plenissima)	Oil mallee	46	23	10
<i>E. microcarpa</i>	Grey box	45	13	11
<i>Chamaecytisus palmensis</i>	Tagasaste (or tree lucerne)	24	64	12
<i>Ceratonia siliqua</i>	Carob bean	11	65	13

* Moderate salt tolerance **High salt tolerance

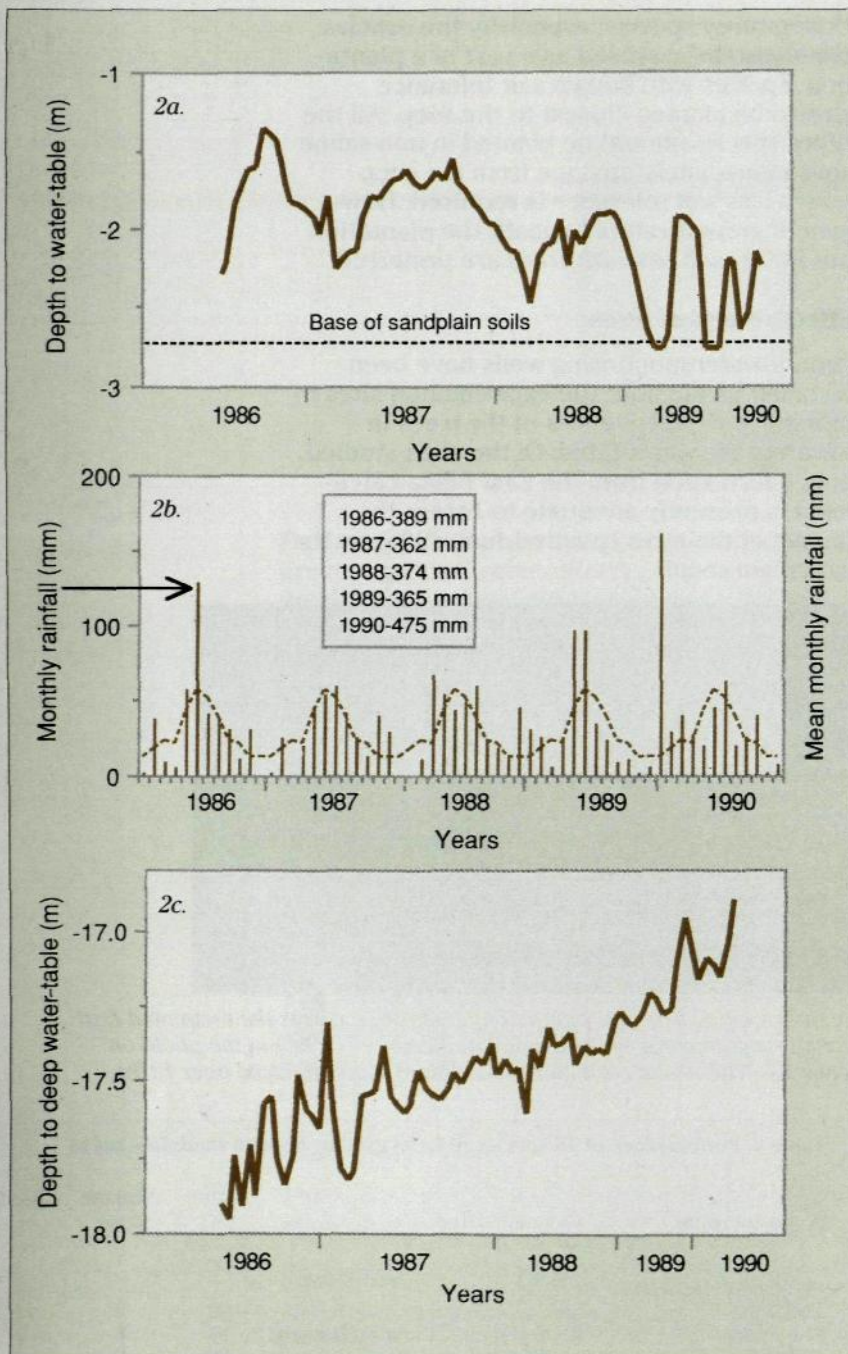


Figure 2a. The seasonal and five-year response of the shallow water-table under the trees. The annual minimum and maximum water-levels have fallen despite above average rainfall. In 1989 and again in 1990 during summer, the perched aquifer was dry.

Figure 2b. The annual and actual monthly rainfall at the East Belka site. The annual average is 330 mm, however, over the five years, rainfall was 59, 32, 44, 35 and 145 mm above average.

Figure 2c. The steady rise in the deep water-table under the plantation in response to general recharge in the catchment. The rate of rise is about 0.2 m per year.

In Figure 2a, the level of the water-table of one bore (ABO1A) located immediately below the plantation shows a steady decline over the five-year monitoring period. Peak water levels in June 1986 were only 1.3 m from the soil surface when the trees were planted. However, by 1990, when the trees were four years old, the water-table remained more than 2.2 m below the soil surface despite above average rainfall during the study period (Figure 2b). More importantly, the shallow aquifer dried out for the first time in 1989 and 1990. The average rainfall at the site is about 330 mm per year.

The steady drop in water-tables in the shallow aquifer within the sandplain soils is not reflected by the water-table levels in the deep bores. In most deep bores beneath the sandplain seep (for example ABO1C), water-levels are rising at about 0.2 m per year (Figure 2c). Management of the shallow aquifer is likely to be inadequate to control rising water-tables in the deeper system, though the prevention of recharge from the shallower aquifer to the deeper one by control of sandplain seeps is advantageous.

Catchment management, including broad scale tree planting, groundwater use schemes and sound agronomy, is needed to control the deep aquifer.

Measurements were also made at the Wyalkatchem and Burakin sites to determine whether tree plantations had dried up perched groundwaters. In both cases, 6 to 15-year-old eucalypts had dried the area below the trees and reclaimed the seep within four to seven years. At Wyalkatchem all of the five-hectare seep and adjacent area had been planted to trees, while at Burakin a small, one hectare seep had been reclaimed.

Reclamation

Cropping and pasture growth have been negligible for about 20 years on the East Belka site. In the landholder's opinion, the site was continuing to degrade. The salt-affected area covered five hectares, and the waterlogged area downslope, seven hectares.

Erosion from the bare saline soils had caused rills to form. On the basis of the lower water-levels of bores in the plantation and in the sandplain seep, the salt-affected area was planted to wheat in 1989. Soil samples taken in the germination zone in the seep before seeding showed mean soil salinity levels had

been reduced from more than 100 to 150 mS/m in 1986 to less than 40 mS/m in May 1989.

The site was cultivated several times on the contour to even out the ridges caused by rilling, and the wheat sown after opening winter rains in May. Despite heavy and erosive storms in June, the crop yielded over one tonne per hectare.

In 1990, heavy rains (162 mm) in January caused some sheet erosion of the sandplain seep, and briefly raised water-tables and redeposited salts in the root zone across some of the seep. However, despite this, barley established on the seep and produced a valuable fodder crop. The area will be planted to wheat again in 1991.

Tree management

The future of the tree belts will depend largely on their ability to cope with the groundwater salinities within the root zone. At Wyalkatchem, Burakin and Mt Walker, where older trees are still growing above remnants of sandplain seeps, groundwaters range from 360 to 1100 mS/m and sites have been reclaimed.

At these sites, species such as *E. camaldulensis* appeared able to cope with high salinities over long periods. Problems associated with toxic levels of salts have not developed to date. This may be the result of the annual flushing from winter rains and the leaky nature of the underlying hardpan.

Conclusions

Experimental evidence and field observations have shown that sandplain seeps have been reclaimed using strategically placed plantations of eucalypts. It appears that this management technique may be suitable for at least 10 per cent of the State's wheatbelt salinity problem, while also reducing groundwater recharge to the deep aquifer.

Small blocks of trees have been able to withdraw large volumes of fresh to brackish water without detrimental effects on the trees while returning the previously saline land to production within five to seven years. The plantation design allows the reclaimed area to be greater than the area occupied by the plantation, while gaining other advantages of wind erosion control, stock shelter and the reduction of waterlogging, water erosion and runoff from the sandplain seep.

Acknowledgements

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Further reading

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Harvesting lupins and barley on the East Belka seep. The trees in the background were 4.5 years old in December 1990.