
An experiment using red gums is aiming to show how salt accumulates in the soil.

# Adding trees to the cropping equation

Down in the depths of the Pye Laboratory, at the Black Mountain home of CSIRO Land and Water, plant physiologist Dr Richard Stirzaker is conducting an experiment that would send a chill through any tree-liberationist.

Side by side, under blazing lights, three river red gums (*Eucalyptus camaldulensis*) are growing in slim cylinders containing a slightly saline watertable (2 dS/m).

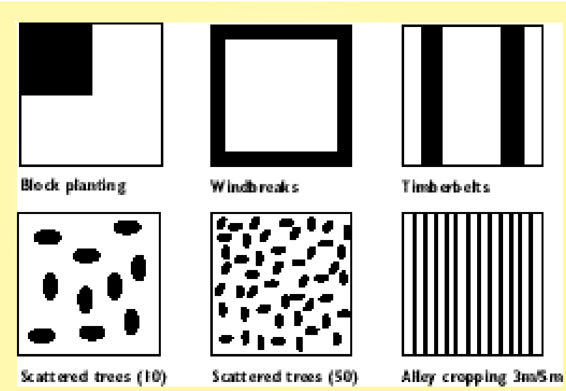
The trees are avoiding the salty poison by taking up mostly fresh water as they transpire, but the excluded salts are slowly accumulating at their roots. One tree has used nearly 5 m of water from the watertable and the salinity of the soil has risen to two-thirds the level of sea water (36 dS/m).

Eventually the trees will drop their leaves and die, as is happening on badly salt-affected land across Australia. Like forensic pathologists, Stirzaker and his colleagues will then examine the salty evidence in the cylinders, seeking clues to the trees' demise.

'In this experiment we're simulating the rate and volume of water uptake from a salty watertable,' Stirzaker says. 'We need to find out where salt concentrates in the root zone, how long the trees will survive, and how this is affected by soil types.'

Data collected by Stirzaker's team will aid the design of tree plantations for saline discharge areas where the watertable is shallow (2-5 m) and fresh to moderately saline (0-10 dS/m). Before investing in such a venture, landholders need to know whether the trees would reach a harvestable size before succumbing to salt accumulation.

Salinity control strategies for many farms combine tree plantations with cropping and grazing enterprises. The aim of such plantations can be to reduce recharge to groundwater tables by intercepting the vertical and horizontal flow of water in the soil profile, to make productive use of saline discharge areas, or to draw down the watertable in areas where it is close to the surface.




**Six ways of putting 25% of the land back into deep-rooted vegetation. The length of the tree-crop interface on one hectare of land increases from 200 m for the block planting to 2500 m for the narrow alleys. The water use of trees in plantations is better understood than that from scattered trees or strips where advection, lateral root growth and subsurface lateral flow of water are important. (Diagram reprinted with permission from RIRDC.)**

Trees can also be used in 'break-of-slope' plantings at the junction of steep upper and flatter slopes. Groundwater is thought to mound at the break-of-slope because of a break in hydrologic gradient. The aim is to tap this water source as a means of preventing waterlogging further down the catchment.

The challenge when designing agroforestry systems is to strike a balance in which trees transpire water that is mostly in excess of the requirements of crops (or pastures). If trees are seen to be 'robbing' too much water from crops and pastures, landholders will be understandably concerned about the effects on agricultural productivity.

Competition is at a minimum when the length over which trees and crops interact is low. For example, large blocks of trees are less competitive with crops than the same area of trees planted in narrow strips (see diagram below), but narrow strips have access to more water because they are more spread out across the landscape.

The critical issue in balancing deep drainage control with competition is to understand the degree to which water moves vertically and horizontally. Where there is substantial horizontal movement, water can move from cropped areas to treed areas, so competition can be minimised.

Richard Stirzaker and his CSIRO colleagues Freeman Cook and Dr John Knight have developed a set of simple guidelines for making these calculations under common groundwater conditions.

Stirzaker says the approach gives the flexibility required when key parameters, such as annual drainage or subsoil conductivity, are either hard to measure or subject to large natural variability. It is based on the depth and quality of the groundwater and the saturated hydraulic conductivity of the soil (see diagrams opposite).

Where watertables are below the crop and tree zone, a wide distribution of scattered trees across the landscape is required to intercept water not used by agricultural plants. This may be acceptable on pasture lands, but not on high productivity cropping land, unless the trees have an economic value to offset the effects of competition. In addition to timber yields, this value includes shade, shelter, animal fodder and the general benefits of nature conservation.

In contrast, trees using water directly from the watertable can induce substantial horizontal movement of water. In this case, belts of trees with alleys between them is the design which minimises tree/crop competition. It is also the design most compatible with cropping machinery.

The spacing of alleys depends mostly on the saturated conductivity of the subsoil: the higher the conductivity, the further apart the trees can be. Alleys between tree belts on light soils can be hundreds of metres apart, but in heavy soils the gap would need to be less than 50 m.

A further consideration under these conditions, which relates back to Stirzaker's work in the laboratory, is the issue

## A: Tree position and groundwater contact

**Agroforestry plantations must use as much excess water as possible, without robbing supplies from crops. Position in the landscape will determine the access of the trees to water and the quality of that water. Trees in upslope regions usually have no access to groundwater. Contact with groundwater can be intermittent at midslope and replenished by lateral movement. Permanent high groundwater of poor quality occurs towards the bottom of catchments.**

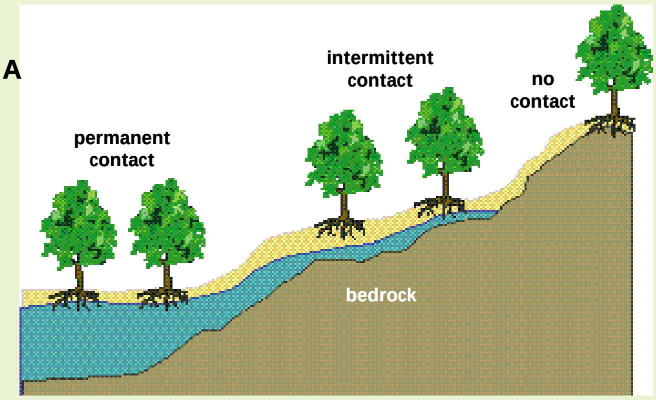
## B: Where trees cannot reach the watertable

**In this paddock, the fringe area beyond the tree roots (capture zone), is a place where competition between trees and crops can be minimised. Trees normally get little water from the capture zone, even when their own root zone is dry, because unsaturated soil transmits water slowly over such distances. During rain, however, the water will move sideways to the dry slab of soil occupied by the tree roots.**

## C: Where trees can reach the watertable

**In this paddock the rising watertable is accessible to the trees, but not the crop. Water used by the trees is replaced laterally at a rate proportional to the saturated conductivity of the soil and the gradient generated by the drop in watertable beneath the tree. Saturated soil is highly conductive, so the trees can influence the watertable over a considerable horizontal distance.**

**Under these conditions, strips of trees with wide alleys between them would be the design most compatible with cropping. The watertable can be held midway between the tree belts, just below the crop root zone. Maximum tree spacing can be calculated using variables such as soil conductivity, watertable depth and annual drainage below crops.**

A
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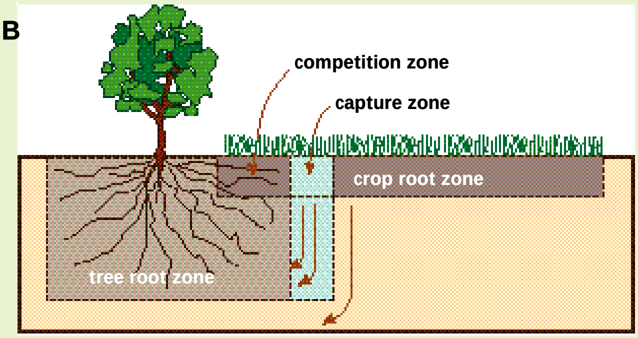


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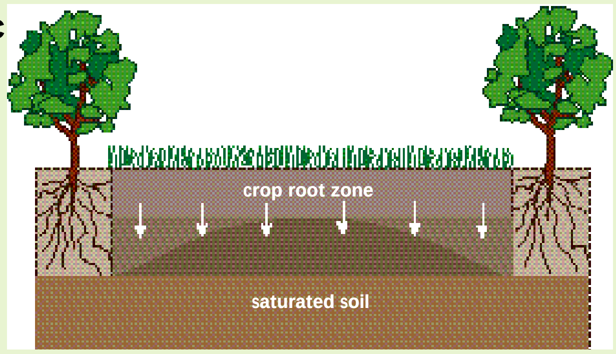


Diagram A reprinted with permission from RIRDC. Diagrams B and C reprinted from *Agricultural Water Management*, Stirzaker RJ Cook FJ and Knight JH (in press) Where to plant trees on cropping land for control of dryland salinity: Some approximate solutions, with permission from Elsevier Science.

of salt accumulation. Because of this danger, viable plantations would only suit sites where groundwater salinity is relatively low (less than 5 dS m), or the uptake rate from the watertable low (less than 200 mm/year), unless the root zone is leached once or twice a decade.

Stirzaker's research will contribute to a technical guide due out next year called 'Agroforestry design guidelines to balance catchment health with primary production'.

The book will present outcomes of a three-year project funded under the Joint Venture Agroforestry Program by the Rural Industries Research and Development Corporation, the Land and Water Resources Research and Development Corporation and the Forest Products Research and Development Corporation.

Dr Rob Vertessy from CSIRO Land and Water is a key investigator for the project which also involves scientists from CSIRO Forestry and Forest Products. He says the project is using scientific insight and predictive models to balance primary production needs with environmental imperatives.

Field research studying relationships between trees and crops and grasses, and between plants, water and soils, is being carried out at Wagga Wagga and Wellington in New South Wales, at Warranbayne, in northern Victoria, and at Katanning and Moora in Western Australia.

In addition to the field research, Vertessy and his team are applying existing models, and building new ones, to make generalisations about how plants, salts and water interact.

'The models will enable the design of agroforestry systems under a variety of site conditions,' Vertessy says. 'Their aim is to minimise negative competition between trees and crops or pastures by specifying factors such as landscape position and planting density.'

Included in the book will be chapters on the benefits and challenges of agroforestry, the principles of plant, water soil interactions, species selection, woodlot design, break-of-slope plantations, alley cropping, the placement of scattered trees and relationships with pasture production. A series of case studies will also be described.

The idea is that agroforestry will be adopted by more landholders if the environmental and agricultural benefits of trees can be maximised. If this can be achieved, the river red gums in the Pye Laboratory will not have died in vain.