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The role of agroforestry and perennial pasture in mitigating water logging and secondary salinity: summary

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Abstract

Clearing of native vegetation for annual crops and pastures is recognised as a major cause of water logging and secondary salinity in southern Australia. A study was commenced in 1995 to evaluate the role of belts of trees, drains and perennial pasture on the water balance, hydrology, water logging and secondary salinity in a duplex-soil subcatchment located in the rejuvenated landscape of southwestern Australia. This summary paper reports on the findings of the integrated research reported in full in this special publication. The belts of trees used an estimated 150 mm more water than was received through rainfall, approximately 30 mm from the surrounding crop and the remainder from groundwater. Lucerne was shown to remove 50–100 mm more water from the soil profile than annual pasture, reducing average annual drainage beyond the root zone throughout the 5-year rotation from 45 mm to 17 mm. At this location, reverse interceptor drains had little impact on water flows at the field scale, but they may have been more effective in other parts of the subcatchment. Calculations suggest that in this region a combination of belts of trees and perennial pasture, such as lucerne, can mitigate and even reverse water logging and secondary salinity while maintaining crop production at near-current levels.

Keywords: Agroforestry; Water logging; Secondary salinity; Drains; Dryland salinity; Duplex soil; Tree belts; Lucerne; Alfalfa

The clearing of native perennial vegetation for the development of agricultural systems based on annual crops and self-regenerating annual pastures is acknowledged as the primary cause of water logging and secondary salinisation of many of the catchments in southern Australia, particularly in southwestern Australia. Estimates by McFarlane and Williamson (2002) put the current area of cleared land in Western Australia affected by

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water logging and salinity at about 1.8 million hectares, or 10% of the area cleared for agriculture. Across southern Australia the total area estimated by McFarlane and Williamson (2002) to be at risk from secondary salinity is about 15.5 million hectares.

The replacement of perennial native shrubs and trees by annual crops and pastures results in rainfall penetrating below the root zone of the annual vegetation and leaking to groundwater. While Australia is the driest continent, southern Australia has a Mediterranean-type climate of cool wet winters and hot dry summers. Annual crops and pastures may not utilise all the incoming rainfall in the wet winter months, as they have shallow roots that cannot utilise the water deep in the profile, and are unable to use unseasonal summer rainfall events. Dunin (2002) suggests that in their pristine state the native vegetation allowed about 5 mm of the annual rainfall to leak past the root zone, thereby keeping the soil below the roots from accumulating salts, but adding little to the groundwater. Studies summarised by Smettem (1998) suggested that agricultural systems in southern Australia allow 20–100 mm of the annual rainfall to leak past the root zone by deep drainage. The increase in deep drainage to groundwater results in a rise in the height of the groundwater ultimately causing water logging, and as the soil below the root zone contains typically 50–5000 tonnes of salt per hectare (McFarlane and Williamson, 2002), secondary salinity often occurs near streams and in low-lying regions of the catchment. McFarlane and Williamson (2002) and Barrett-Lennard (2002) point out that the combination of water logging and salinity has an impact on plant growth significantly greater than either one alone.

The remedies suggested for mitigating water logging and secondary salinity are to reduce the degree of recharge by reintroducing perennial vegetation into the landscape and removing excess water by drains. In rainfall zones with less than 600 mm annual rainfall, it is generally accepted that planting the whole region to trees is not economic due to low growth rates of the trees. So, a combination of various land-use options (annual crops, perennial pastures, trees and drains) needs to be integrated within the catchment. Where this is not feasible or effective, the introduction of halophytic species in the areas of salinity has been proposed. This special publication reports on a series of studies investigating the impact of drains and the reintroduction of perennial vegetation into the landscape, and also reports on attempts to revegetate saline areas.

In 1995, several integrated studies were commenced to determine the impact of trees, drains and perennial pasture on the water balance of a small catchment. The opportunity was taken to conduct the studies on a farm near Katanning in Western Australia, 'Ucarro', on which the owners and managers had established a series of drains along the contour to slow water movement downslope to the low-lying areas adjacent to the streams that were beginning to become seasonally waterlogged and saline. They had also planted belts of trees on the downslope side of the drains to utilise some of the water in the drains and further reduce downslope water movement. Some of the water in the drains was used to fill dams to supply water in the dry season to sheep, grazing the pastures and crop stubbles. Rundle and Rundle (2002), the owners and managers, describe their reasons and the direct and indirect benefits of the system that they adopted. Additionally, a large plot of the perennial species, lucerne (*Medicago sativa*), was established and the water balance and production compared with an adjacent annual pasture plot. Details of the plots, soils and catchments are described in detail by Hodgson et al. (2002).

McFarlane and Williamson (2002) show that the 'Ucarro' farm is located in the upper reaches of the Blackwood river catchment in a region of rejuvenated soils and with a reasonably dissected landscape compared with areas further to the east in the Western Australian wheat belt. Hodgson et al. (2002) point out that the 'Ucarro' farm occupies almost the whole of a small sub-catchment enabling the impact of the drains and trees to be studied at the sub-catchment level.

White et al. (2002) reported that the 8-m-wide belts of trees removed about 150 mm of water more than the annual rainfall, which they suggest was obtained from the fresh groundwater at the site by two of the four species studied. Using these figures, White et al. (2002) calculated that 16% of the catchment would have to be planted to trees to reduce annual deep drainage to the 5 mm that was estimated to occur in the pristine state. Dunin (2002), using a more conservative estimate of additional water use by the trees of 100 mm more than the annual rainfall, estimated that 22% of the catchment would have to be put under trees to achieve the same target.

Belts of trees can also capture rainfall that would be utilised by adjacent crops and pastures. Indeed, a study by Woodall and Ward (2002) showed that a belt of trees reduced crop yields up to 20 m from the tree line and Ong et al. (2002) in a study on another continent showed that root pruning can reduce the access of tree roots to the water utilised by the crops, but yields are not fully restored by root pruning. Further, Burgess et al. (1998) working at 'Ucarro' showed that at the break of season the roots in the crop zone capture the rainfall and at night recharge the dry soil below the trees. Independent estimates by White et al. (2002) and Burgess et al. (2001) suggest that the roots redistribute about 30 mm of rainfall from the crop zone to the soil deep below the trees. This adaptation by the trees, in conjunction with reduced stomatal conductance, is considered by Dunin (2002) to reduce tree productivity by decreasing water use in the wetter months, but allows water use during the hot dry months of summer and early autumn and provides a mechanism for survival in seasonally wet-dry environments.

Ward et al. (2001, 2002) showed that the lucerne used an additional 50 mm of soil water compared to an adjacent annual pasture over the 3 years of the study and reduced recharge by up to this amount. Studies by Latta et al. (2002) in other areas of Western Australia indicated that the lucerne used 50–100 mm more water than an annual pasture. The lucerne not only used out-of-season summer rainfall, but provided a buffer for a subsequent crop so that a 2–3 year cropping phase will have a substantially reduced deep drainage (Ward et al., 2002). Lucerne also provided benefits to subsequent crops through a supply of nitrogen and ease of weed control (Bee and Laslett, 2002). Bee and Laslett (2002) demonstrated a method of establishing lucerne with barley that not only aids the establishment of the lucerne but provides an income stream in the first year of lucerne establishment during which grazing must be limited.

When lucerne is grown in combination with belts of trees, the area planted to trees can be reduced from 16 to 8% when the trees use 150 mm of water more than the annual rainfall (White et al., 2002) or can be reduced from 22 to 12% when the trees use 100 mm of water more than the annual rainfall (Dunin, 2002). Thus, the combination of trees and lucerne over 30% of the cleared area should allow 30% of the farm to be cropped and still maintain recharge to be below 5 mm on average in most years (Poole et al., 2002). Bathgate and Pannell (2002) and Poole et al. (2002) indicate that incorporation of lucerne with crops in the farming system can be economically beneficial. Bathgate and Pannell (2002) suggest that the profitability of lucerne depends on having areas of suitable soils and the frequency of summer rainfall in addition to the price of wool, grains and costs of establishment. Stirzaker et al. (2002) also point out that to induce farmers to establish belts of trees, an economic return from the trees is required. However, Rundle and Rundle (2002) argue that there are sufficient indirect benefits from the trees, such as shelter from the wind, increased lambing percentages and timeliness of spraying, that they are not concerned at the lack of a direct return from the trees themselves.

The presence of the tree belts resulted in little flow of water in the drains in the study area (Hatton et al., 2002). This was in part because the trees not only utilised water flowing laterally downslope, but also aided the vertical movement of water below the trees. As a result of the trees and the vertical water movement through areas of preferred pathway flow (McFarlane and Williamson, 2002; Dunin, 2002) under the lucerne and annual pasture, there was little water logging in the plots and little water collection in the drains. Anecdotal evidence suggested that this was not the case over the whole farm as dams did fill during the wet winters.

However, in flat low-lying parts of catchments, there may be insufficient fall for drains to be effective and the use of belts of trees and perennial pasture may be insufficient or introduced too late to be effective or productive. In these situations the use of halophytes may be the only option available to the landowner for revegetating these areas. Barrett-Lennard (2002) describes a system in which perennial helophytes such as *Atriplex* species can provide some grazing in the dry summer months, and also lower the saline water table. In the following winter self-regenerating, water logging-tolerant annual legumes, such as balansa clover (*Trifolium michelianum*), can be established to use the fresh rainfall and provide productive pasture for winter and spring grazing.

Finally, calculations suggest that the combination of drains, belts of trees and lucerne reduced deep drainage sufficiently to slow the trend for rising water tables, and in this region of rejuvenated soils the combination of drains, belts of trees and a phase farming system incorporating a perennial pasture will not simply slow water logging and secondary salinity, but reduce or reverse secondary salinisation (Silberstein et al., 2002). Moreover, such systems can be economically viable. This strongly suggests that agriculture in at least parts of southern Australia can be both productive and sustainable.

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